

Breaking the Sound Barrier: Explorations in Experimental Sound Art, Soundscape Research and Interactive Systems

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A Thesis

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ABSTRACT

This study proposes a synthesis between the three core inter-disciplines of sound art, interactive systems and soundscape research as the basis for the creation of a series of unique interactive sound installations and related projects. These works, created and presented by Interactive Agents, the author's production company, explore aspects of the sonic environment, either in urban or natural locations or in the electro-magnetic domain.

The notions of interactivity explored throughout this thesis are of a specialist nature, and the three main installation projects each utilise custom-built solutions, which eschew widespread computer technologies for discrete electronics, ensuring the seamless integration of artistic intention and interactive realisation. The sublimation of certain technological elements is explored as means of encouraging an audience to approach a work on its own terms unencumbered by everyday technological experience. The concept of an audience member is itself re-cast as an InterActor, at once a listener, viewer and performer and it is with reference to this term that the audience's experience and impact on a work is conceived, deployed and evaluated.

The sound material of each of the projects range from sonic reflections of the Stockholm soundscape elicited from its inhabitants to sonifications of electro-magnetic phenomena related to the operations of the Earth, the Sun and the wider universe. In certain cases the examples incorporated into the works were created by leading research scientists and thus this study not only repositions the outcomes of scientific research as artistic material, but also suggests that, in so doing, something of the classical unity between the arts and the sciences is regained.

The thesis is presented in seven chapters, with the descriptions of the practical works preceded by an introductory chapter that explores related theoretical and contextual issues. The thesis culminates with a consideration of the development and reception of an exhibition where the sonic and interactive strategies discussed were presented.

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Chapter 1 Introduction – Theory and Context

1.1 Prelude for Trumpet and the Rest of the Universe



Fig.1.1: The Queen's Tower, Imperial College,
South Kensington, London

The Queen's Tower stands like a vast, neo-renaissance folly in the central quadrangle of Imperial College in South Kensington, London. Completed in 1893, this Italianate structure, rendered somewhat incongruous given the nature of the architecture that now surrounds it, is the final remaining element of the Imperial Institute, which was demolished in the early 1960s

when the present college was built. The tower was only saved from demolition due to the activism of Sir John Betjeman.

The following discussion of the theoretical and contextual frameworks relating to the development of the series of interactive sound installations and related projects begins at the tower, for it was here, in 1997, that I proposed to create a site-specific performance for solo trumpet, ensemble and electronics. It was envisaged that during the performance the trumpet soloist would ascend the tower and the work would culminate in the sound of the trumpet being bounced off the surface of the Moon.

The proposed *Moonbounce* project was derived from a technique known to many of the more accomplished amateur radio enthusiasts as Earth-Moon-Earth (EME) or Moonbounce communication which involves using the Moon as a passive communications satellite. This is achieved by arranging two yaegi antennae in a complex send and receive configuration, which in musical terms, would create a natural delay loop of around 2.5 seconds.

The work was never realised and was finally abandoned due to a

number of technical and financial problems with successfully achieving EME communication in real-time performance that (at the time) appeared prohibitive¹. However, the work also presented a set of purely musical problematics that I felt were never fully resolved or explored, involving the integration of space radio phenomena into a musical discourse.

The extant sketches of musical material for the piece illustrate a number of attempts at achieving this synthesis. One example (included here as Fig. 1.2) is an excerpt from the first movement and shows the intention to include the sonified output of a radio telescope, channeling space radio background noise as a foundational element of the sonic architecture.

¹ The project was finally abandoned when in 2001 I met Pauline Oliveros at a conference at Dartington, and discovered that she had completed such a project in 1987, albeit one that substituted my proposed use of the trumpet for the sound of her accordion. *Echoes from the Moon* was premiered as a performance/installation at the Mobius Gallery in Boston and later again in St. Polten, Austria in 1999.

The Moonbounce concept was used again recently as the basis of a sound installation by Katie Paterson entitled *Earth-Moon-Earth (Moonlight Sonata Reflected from the Surface of the Moon)* (2007). This work involved translating the first movement of Beethoven's famous work into morse code, bouncing the code off the Moon and then translating the received version back into music, then programming and playing the result on a Disklavier (Paterson, 2007).

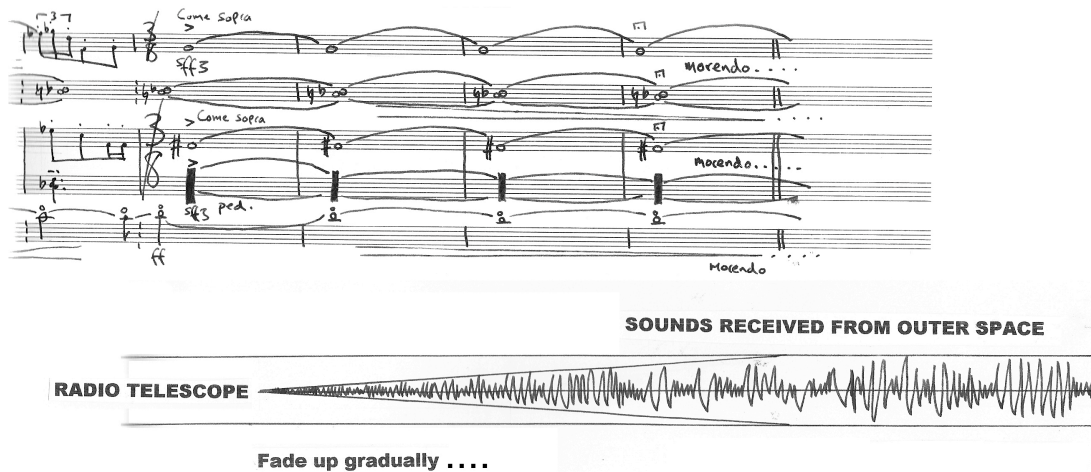


Fig. 1.2: Robin McGinley: Sketches for the unrealised *Moonbounce* project (1997). This excerpt from the first movement for solo trumpet and ensemble shows the first entry of the radio telescope. The mediated output of the radio telescope was to be harnessed either through pre-recording or through some form of live-feed arrangement.

However, I became increasingly dissatisfied with these kinds of juxtapositions of traditionally-oriented notational or performance practices with radio astronomical elements, not least of all because the inclusion of such elements seemed to demand an approach to musical organisation beyond that of fixed, horizontal or vertical note-to-note (or even sound-to-sound) relationships and also suggested durational parameters that potentially far exceeded those which are generally associated with musical performance. Added to this was the contention that, unless I was content with relegating these mediated sounds to the level of mere musical effects, what these sketches actually represented were my attempts to place these

elements within (from a galactic or cosmological perspective) fairly arbitrary musical structures.

It would be some years before I would begin to reason that perhaps what was required was a move beyond strictly musical discourse by the creation of artistic situations in which these mediated sonic phenomena could be presented and experienced more on their own terms, uninhibited by the constrictions of traditional musical (and attendant audience receptive) praxis. This was to become one of the primary considerations in the evolution of the research project that this thesis documents. The intention with invoking the abortive *Moonbounce* project here is to illustrate that within it are contained a number of the key concerns of the present document in microcosm or in earlier forms. For example, the sonic characteristics of the background radio noise furnished by the radio telescope above is essentially similar to that of the Cosmic Microwave Background (CMB) radiation in what was to become the interactive sound installation *The Hydro-Acoustic Big Bang Filter* (2007) (see Chapter 3), although I would not have referred to it as such a decade earlier.

The project was also the last in which I wrote for traditional

instruments, using a mix of traditional and graphic notations. From there I moved, briefly, to purely electro-acoustic means and thence to investigating the possibilities of creating interactive sound installations. One of the subthemes of this document is thus the shift from experimental instrumental and electro-acoustic composition towards collaborative interactive sound installation practice.

1.2 Orientation

In this thesis I shall discuss the development of a series of five interactive sound installation projects created in collaboration with Interactive Agents (a production company originally founded for the purpose of constructing these projects) that together form the practical portfolio. Approximately in order of construction, these are:

The Earth's 4.5 Billion Year Old Electronic Music Composition (2002)

The Hydro-Acoustic Big Bang Filter (2003 – 2007)

The Cosmic Phonograph (2004)

Stockholm Sound Sanctuaries (2004 – 2005)

The Heliosonic Resonator (2007)

The original intentions of this project were to involve a practical exploration of the concept of *soundscape composition* in terms of the creation of electro-acoustic music and the three large-scale installation projects each retain somewhat the soundscape dimensions of this study, whilst projecting the concept beyond the envelope of human perception by exploring certain mediated electro-magnetic phenomena and cosmological data sonifications.

The Earth's 4.5 Billion Year Old Electronic Music Comoposition is based on Very Low Frequency (VLF) recordings of electro-magnetic discharges in the atmosphere generated by lightning storms; *The Hydro-Acoustic Big Bang Filter* (together with the preparatory study *The Cosmic Phonograph*) utilises a sonification of the Cosmic Microwave Background (CMB) radiation created by Professor Mark Whittle at the University of Virginia. This radiation is believed to be residual of the Big Bang itself. Whilst *The Heliosonic Resonator* is based on sound material created by NASA researchers through the sonification of data collected by the Solar and Heliospheric Observatory (SOHO) spacecraft, which monitors (amongst other things) seismic activity within the interior of the Sun.

The concept of the soundscape is approached from a more terrestrial

perspective through the *Stockholm Sound Sanctuaries Project* which applied a concept developed by the Canadian electro-acoustic composer and soundscape researcher Barry Truax to the contemporary soundscape of Stockholm, Sweden through a public sound art research project which I undertook at The Swedish Royal University College of Fine Arts (Kungliga Konsthögskolan) in 2004 – 2005 (see Chapter 5).

In this opening chapter I shall present an overview of the theoretical and contextual issues that relate to the above practical works. These include a consideration of the use of sonification as the basis of an approach to the creation of sound art, together with a discussion of the deployment of sonically-mediated space radio phenomena within a sonic arts context and a consideration of selected approaches to sound installation practice and attendant issues of sound artists' conceptions of artistic space.

I shall also present the range of interactive strategies that form the basis of the systematic operations of the installation works. These are of a specialist nature, as they completely eschew widespread computer-based platforms in favour of custom-built systems created from discrete electronics. The concept of the audience member is also envisaged as a

composite of the functions of listener/viewer/performer and thus re-cast as an InterActor, a term that originates with Interactive Agents.

The contextual ramifications of the concept of soundscape (as mentioned above) will also be considered, as will ideas relating to the concepts of nostalgia and retrofuturism and their relationships to certain aspects of the practical works. This chapter concludes with an exploration of the concept of collaboration as it is understood to relate to the creation and development of the works under discussion.

Following this opening chapter, details of the physical nature, development and construction of each of the practical works will be presented in turn (Chapters 2 – 6). In Chapter 7 (the concluding part of this thesis) I deal with the development of an exhibition of these pieces entitled “Radioworks: New Directions in Sound Art by Interactive Agents” and the reception of these works by the audience is also explored. The exhibition took place over a three-week period at SHUNT Vaults, a vast ex-bonded wine vault under London Bridge Station during May 2007. Additionally, audio-visual documentation of the works (created during the exhibition) can also be accessed on the DVD that accompanies this thesis.

1.3 Sonification and *Found Sonification*

“Sonification is defined as *the use of nonspeech audio to convey information*. More specifically, *sonification is the transformation of data relations into perceived relations in an acoustic signal for the purposes of facilitating communication or interpretation*. By its very nature, sonification is interdisciplinary, integrating concepts from human perception, acoustics, design, the arts, and engineering.”
(Kramer G, et. al., 1999)

An interdiscipline with an increasingly discernable profile and a vast array of industrial, medical, scientific, academic and design applications, sonification offers new approaches to complex data handling and, as the examples of space science sonifications utilised in the practical works of this study illustrate, is progressively used as an alternative to data visualisation techniques for the purposes of data analysis. This is especially true of situations where large amounts of data have to be processed while the eyes are otherwise engaged (e.g. an aeroplane cockpit) or where dynamic changes in data distribution are to be observed over time.

The proliferation of these concepts together with the huge increase in available computational power over the past decade has meant that sonification has also become a viable field for artistic exploration. This is especially true in the fields of music technology and sound art,

understandably perhaps because the very act of manipulating representations of sonic material in data space has for many artists and composers become a key factor of artistic creation.

The data sonifications explored and deployed in the practical works associated with this study are of a specific type and are drawn either from astrophysical or cosmological research or involve the sonic mediation of electro-magnetic atmospheric phenomena through radio reception. Similarly, there are a number of recent examples of sound artists using similar approaches as the basis for the creation of sound installations.

One example of such artistic application is Owain Rich's *Weatherlayer* (2002)² that is characterized as a generative sound installation to be accessed online and consists of a set of external hardware components that monitor a number of meteorological variables including temperature, light, wind-speed and water. The resultant control voltages are converted into MIDI information and used in the real-time generation of the sonic material for the work, achieved algorithmically through custom-written software created in

² This work was part of a group exhibition that included Interactive Agents' *The Earth's 4.5 Billion Year Old Electronic Music Composition* at Golden Square Gallery, London as part of the inaugural Cybersonica Digital Music and Sound Festival in 2002.

the SuperCollider programming environment (Rich, 2002).

A similar approach is taken by Natasha Barrett in her audio-visual work *Displaced: Replaced II* (2002), first presented at ICMC2002 in Gothenburg and likewise based on harnessing meteorological data monitored by a number of remote sensors, translating the resultant control voltages into MIDI information to govern the temporal deployment of a series of four and eight-channel stereo and ambisonic sound files in the gallery space. In addition the work combined this sonic material with projections of real-time and pre-created graphical visual images also controlled and modified by the incoming data streams to create what Barrett describes as “a mimetic abstraction of the meteorological source, projected through sound and vision within the space” (Barrett, 2002). This work also approaches notions of displacement as the meteorological sensors were based in Oslo, with the data streams being transmitted to Gothenburg Art Museum via the Internet.

There are a number of issues regarding the use of sonified data as sound material, not least given the slightly cerebral nature of the data conversion processes involved and whether or not the correlation between the original

natural phenomena and the sonic resultant is successfully communicated to an audience on the perceptual level, as Simon Emmerson has commented:

“All sonification of events that cannot in their original form be heard, or which are heard in a substantially different form, are metaphorical transcriptions. [...] This is true even for sound events outside the audible range. We cannot strictly say ‘this is what the ionosphere sounds like’. Too many such sonifications are presented without the translation to the sound we hear being made explicit (in an accompanying note.)” (Emmerson, 2007: 59).

Further to this we can also state that the utilisation of these sonified data elements profoundly affects the conceptual aims of a work, as an artist is effectively inviting the audience to accept the metaphorical transcription presented as a valid analogue of the original phenomenal source. It is through this kind of acceptance that an important facet of the artistic intention and operation of meaning within the work is appreciated.

Towards this end, each of the instances of the use of sonified data in the practical portfolio were pre-existing (with the exception of the mediated EM radiation in *The Earth’s 4.5 Billion Year Old Electronic Music Composition* which was achieved through direct VLF radio reception). Many of the sounds incorporated were created by space scientists or cosmologists for the purposes of data analysis in the course their own research. For the purposes of this study, I characterise these pre-existing sonic materials as *found*

sonifications, a term derived from the use of the concept of the *found sound* in music, especially electroacoustic music. This disposition thus points to the existence and manipulation of ‘real-world’ elements within an artistic context (a common factor with the functioning of the general concept of sonification in the work examples cited above).

The act of creation based upon existing sonic material can also be understood in terms of the notion of *postproduction*, a perceivable trend in the creation and presentation of contemporary art that Nicolas Bourriaud has defined and identified with the practice of artists who:

“interpret, reproduce, re-exhibit, or use works made by others or available cultural products. The art of postproduction seems to respond to the proliferating chaos of global culture in the information age. [...] These artists who insert their own work into that of others contribute to the eradication of the traditional distinction between production and consumption, creation and copy, readymade and original work. The material they manipulate is no longer *primary*, it is no longer a matter of elaborating a form on the basis of a raw material but working with objects that are already in circulation.” (Bourriaud, 2002: 13).

Although Bourriaud makes the above comments primarily with reference to the use of other artworks and cultural products it is proposed that this situation is equally applicable to use of the outcomes of scientific research. Indeed, a similar appropriation of space science sonifications formed the basis of the project *Radio Astronomy* (2004) by the New Zealand-based

collective Radioqualia. This project procured output signals from a number of radio observatories and was presented both as online and on-air broadcasts and as sound installations at the ICC in Tokyo and subsequently at the ISEA and Ars Electronica Festivals 2004 (Radioqualia, 2004). In this project the sonified materials are not only used to metaphorically reference cosmic phenomena, but can also be viewed as *sonic tropes*, which represent the notions and concerns of the space research from which they are derived. It is in this sense (with reference to the sound installations discussed herein) that I propose the notion of the re-contextualisation of the sonified space data (originally intended for the purposes of scientific analysis) as art, through the act of placing it within an artistic discourse.

1.4 Sci-Fi Resonances in a Musical Context

“Electronic music has been associated with science fiction filmmaking from the very earliest, pre-synthesiser experiments in the 1950s. From then up to the mid 1970s, electronic sounds were to the general public terribly exotic, mysteriously technological, futuristic and “scientific” – a combination of features ideal for science fiction” (Stiller in Keman, J.B., 1991 (ed.): 197).

Further to these conceptual considerations regarding their providence, these sound materials were also selected for appropriation for their purely sonic characteristics. The development of this approach can be traced back to the development of the first installation work *The Earth’s 4.5 Billion Year Old*

Electronic Music Composition (see Chapter 2). A prominent sonic element in this work is the pre-recorded VLF ‘whistler’ emissions, generated by EM pulses caused by distant lightning strikes, being ducted out into space around the Earth’s magnetic lines of force, before arriving at the receiver location. I was struck by the similarity of these various species of sliding pitch event (effectively mediated naturally-occurring phenomena giving rise to electronic glissandi) to the output of certain early analogue synthesisers, hence the ‘electronic music composition’ analogy.

Furthermore, these sounds also seemed to have a certain resonance to the extensive use of electronic sound producing means in the soundtracks of numerous science fiction films from the 1950s onwards. Archetypical examples such as Bernard Hermann’s use of Theremins in the score to *The Day the Earth Stood Still* (1958) or the custom electronics utilised in Louis and Bebe Barron’s realisation of their soundtrack for *Forbidden Planet* (1956), were seminal in fixing within the collective pop cultural consciousness the connection between electronic music and the science fiction moving image genre. A correlation being increasingly researched and explored in recent research literature relating to film music studies (Hayward, 2004 and Wieizblecku, 2005).

It seemed wholly appropriate that there should be this apparent connection between the sonic derivatives of the propagation of EM radiation through space and this particular film genre, with the examples cited above being considered indicative of a certain kind of technological nostalgia that became increasingly important for the development of the practical works (see section 1.8 of the present chapter), not only through subtle visual referencing to sci-fi films within the installation structures, but also the fact that, given the ubiquity of today's electronic musics, it may no longer allude to concepts such as the 'future' or 'technological progress'. Moreover, these allusions may be staged as a means of signifying the future as it once may have been envisioned, akin to what has been described as *retro-futurism*.³

In any case, this sonic connection was deployed throughout the first installation work (and many of the subsequent ones) in a variety of ways. Firstly, it established a means for the situating of the idea of 'outer space' and 'astrophysical/cosmological phenomena' directly within a musical or sound art context (a primary concern that had been residual from the abortive *Moonbounce* project). Furthermore, this act of placement not only

³ This term is further defined and discussed in section 1.8 of the present chapter.

operated conceptually, but also is apparently embodied within the sonic material itself. Thus, the whole is lent a kind of *hyperreal* quality, through the alignment of a straightforward documentation of an electro-magnetic physical phenomenon with a science fictional sonic archetype.

1.5 Extensions of the Soundscape

The *soundscape* dimensions of this study originated with an education project for secondary school students in Stockholm that I devised and delivered in Autumn 2000 (McGinley, 2001)⁴. The aims of this project were to apply research methods initially developed within the field of soundscape studies directly within a secondary school curriculum, encouraging the participants to document and engage with their local soundscape by writing sound journals, creating sound maps and making field recordings. It is entirely appropriate that my own engagement with these issues should stem in this way from pedagogical work, as such concerns have been central to this field since its inception.

⁴ This project became the basis for a national schools project in Sweden “Lyssna till vad du hör” (Listen to what you hear), presented at a number of schools across the country in 2001-2002. Subsequently the project became one of the main models for the Sonic Postcards project in the UK, presented by Sonic Arts Network and commencing in 2004.

The term, created in the late 1960s by R. Murray Schafer (Schafer, 1977), who subsequently led the influential World Soundscape Project at Simon Fraser University in Vancouver throughout the 1970s, was intended as a tool for helping to conceptualise everyday sounds as the basis for interdisciplinary research. The aims of such research were to be, at once a positive approach to contemporary problems of noise pollution, and also a means of bringing artistic and musical compositional approaches to bear on the sound environment, to promote ways in which it might be improved. Indeed, the dichotomy of the artist and the activist has been something that has haunted this field ever since and has perhaps been one of the factors that has prevented much of its associated terminology from ossifying into strict, uncontested and established definitions. This is an area in flux and has been so ever since its inception, with debate raging between subsequent practitioners as to the possible definitions and significance of concepts such as *acoustic design* and *acoustic ecology*.

Following the production and publication phase of the original project in Vancouver, these ideas began to find increasingly widespread resonance in the early 1990s, leading to the establishment of the World Forum for Acoustic Ecology (WFAE) at the first international acoustic ecology

conference at Banff in 1993 (WFAE, 1993). Subsequently, the second international conference took place in Stockholm in 1998 (Karlsson (ed.), 1998). Reading the proceedings from this conference was an important catalyst to my own involvement in this area and Henrik Karlsson, the conference organizer (then Head of Research at The Swedish Royal Academy of Music) was particularly supportive during the development of the national education project (based on my original version) which was presented by the Swedish community education group Artists and Musicians Against Tinnitus (AMMOT) at a number of schools throughout Sweden in 2001 and this gave rise to a Swedish language handbook for teachers detailing delivery strategies for the project which was published in 2003 (AMMOT, 2003).

Having completed work on the primary incarnations of the education project, I was keen to apply notions of the soundscape to my own creative work. Since abandoning the *Moonbounce* project in 1998 (as mentioned above) my compositional practice had become almost exclusively electro-acoustic in nature, being mostly realised in the studios of the Institute for Electro-Acoustic Music in Sweden (EMS). Thus, the practical research outcomes related to this current project were originally intended to be in the

area of *soundscape composition*.

According to Barry Truax (Truax, 1984: 207) the term soundscape composition was first coined by the group of composers connected with the original World Soundscape Project and it has achieved widespread usage in the intervening thirty years, with Truax subsequently proposing that the term has expanded to encompass a continuum of interrelated compositional practices:

“At one end of the continuum of soundscape composition practice is the ‘found soundscape’ or what is referred to as phonography – that is recorded soundscapes with minimal or no alteration that can be listened to as music in the sense of an organised sound structure with differing levels of meaning. [. . .] At the other end of the continuum I have proposed is the abstracted soundscape which remains clearly identifiable as to subject matter, but which incorporates sonic elements that have been abstracted to varying extents from their original source” (Truax, 2008: 103).

The diffuse nature of the term is also apparent to several other practitioners and the problems of arriving at an adequate definition, encompassing such a wide field of activity, whilst also connecting it to the broader aims of acoustic ecology, has been addressed by many, including Hildegard Westerkamp (Westerkamp, 2003) and John Drever (Drever, 2002). This open, fluid situation seemed particularly suited to my own compositional practice which, in itself was still in a period of transition during 2001 when I

began experimenting with these issues in the electro-acoustic studio. Within a year I began to concentrate, almost exclusively, on the creation of sound installations.

Even though the nature and presentational contexts of the practice changed, certain aspects drawn from soundscape composition could be said to remain. This is especially apparent if one considers that at a foundational level, much soundscape compositional practice is derived from an engagement with sound material drawn from the sonic environment, where contextual and associative aspects of the sounds utilized inform and shape the conceptual aims of a work, and that such works are often presented through situations that are technologically mediated (i.e. through loudspeakers). Furthermore, the function of technological mediation with respect to the installation works became even more important once the decision had been taken that, rather than focus on naturally-audible acoustic sound sources, the works would explore natural phenomena that could only be rendered audible by technological means. Thus, technological mediation is implicated both within the choice of sound material and in the chosen modes of presentation.

The everyday, naturally – audible sound environment remains an area of concern within the practical portfolio, however, with regards to *The Earth's 4.5 Billion Year Old Electronic Music Composition* which presents a composite palette of mediated and naturally – audible sound material, and especially the *Stockholm Sound Sanctuaries* Project (see Chapter 5), which was realised as a public sound art project based on the *acoustic sanctuaries* concept of Barry Truax (Truax, 1984). This involved organizing a public survey to identify areas of relative quiet and reflection within an otherwise noisy city soundscape. The results of the survey (which was carried out online and through a series of suggestion box installations throughout the city) were documented through a series of field recordings and presented as an online sound map through which the recordings could be accessed. This project was conceived in 2001, directly after my work with the education projects mentioned above and immediately preceding the commencement of the first installation project in 2002, although was not realised until 2004 when it became the basis for a research project at the Swedish Royal University College of Fine Arts (Kungliga Konsthögskolan).

The public survey aspects of this work were also partially influenced by the British sound artist and musician Peter Cusack's *Your Favourite London*

Sounds project (Cusack, 2001), originally commissioned by London Musician's Collective for the launch of their experimental radio station Resonance FM. This project is an attempt to gauge Londoner's engagement with their local soundscape by asking them to nominate their favourite sounds and the reasons for their choice. Many of the sounds nominated were subsequently documented by Cusack as the basis for a CD release and website. This concept has since been exported to other cities around the globe such as Chicago and Beijing, illustrating the ease with which such ideas are able to proliferate internationally. In 2007 it was also presented in Manchester as part of the Positive Soundscapes Project, an interdisciplinary research initiative based at the University of Salford, UK, exploring and enhancing 'positive' aspects of the urban sound environment as an alternative to what is seen as the more negative approaches of noise control legislation (Positive Soundscapes Project, 2006).

Such initiatives can be seen to resonate sympathetically with the original aims of the soundscape movement, at once encouraging an urban populace to become aware and (in some cases) actively engaged with the soundscape, whilst highlighting the proximity of artistic intervention to social science or urban planning research.

1.5.1 The Electro-Magnetic Soundscape

As mentioned above, the gradual shift of practice towards sound installation was accompanied by a greater focus on what we may describe as technologically-mediated sound materials. This development can again be traced back to the earlier *Moonbounce* project and was coincident with a revival of interest in the potential use of space radio phenomena within a sonic arts context. During the development of this previous project, I became aware of a number of techniques used by amateur radio enthusiasts for listening to various kinds of space phenomena on cheap, self-assembly receivers and equipment. One of these techniques involved making recordings of electro-magnetic discharges within the ionosphere caused by lightning storms using a Very Low Frequency (VLF) radio receiver and an extensive amount of copper wire as a makeshift antenna. These became the primary tools for making the field recordings that formed the basis of *The Earth's 4.5 Billion Year Old Electronic Music Composition* (2002) (see Chapter 2) and it is through associated means that several other sound artists have departed from the sphere of the naturally-audible sound environment to

explore, and make manifest, what we will define here as the electro-magnetic soundscape.

The exploration of the pops and crackles of *sferics* (short for VLF atmospherics) emissions and the ethereal sliding pitch events of the associated *whistler* tones within electronic music and the sonic arts has a fairly long history. Dating back to the late 1960s when Alvin Lucier made his first field recordings (with the assistance of Pauline Oliveros) for what was to become the first of many versions of his work *Sferics* (Lucier, 1988). Lucier continued to make recordings of sferics into the 1980s and used this material in a variety of forms as the accompaniment to dance performances, multi-channel versions for concert presentation and even as the basis for a real-time sound installation at El Moro, New Mexico in June 1984, for which:

“A small array of antennas was set up at a campsite on top of a mesa. The incoming signals were routed through the amplifiers of battery-powered cassette tape recorders to several pairs of headphones, so that visitors could listen to the sounds of the ionosphere throughout the night.” (Lucier, 1988).

Similar field recording techniques have also been investigated extensively by the London-based sound artist Joe Banks, working under the project

name Disinformation. Banks' project encompasses CD releases, performances and sound installations, many of which are characterised by their use of electromagnetic radio noise, not only from lightning, but from such sources as coronal ejections from the Sun, electronic circuitry, power lines, railway lines and the National Grid. The diversity of sonic phenomena that can be evoked by a modest amount of VLF listening equipment, together with the rich array of conceptual associations that he brings to his recordings are exemplified when he comments that:

“Tuning down into the lowest reaches of the radio spectrum, particularly in night's shadow of the solar wind, the listener enters a world of diverse phenomena, opening an acoustic window on a world alive with electrical activity. VLF whistlers from lightning and thermonuclear EMP ricochet along field lines of the magnetosphere, bouncing between hemispheres of the globe; storms crackle: biostatics whisper, hiss and sigh: televisions scream: pylons and power loops drone and roar: military signals, the musical pulses of navigation systems, timecodes, and coded data broadcast deep beneath the sea. Time and space divided, live ‘vivisection’ of particle physics, voices, map lines, weapons, mirrors hidden by the illusion of quiet.” (Banks, 1996)

Central to much sound work derived from the electro-magnetic domain is the desire to make audible that which is usually inaudible, to sonically manifest the invisible radiation which continually surrounds our everyday urban existence and expose an alternative ‘sonic’ reality, below and beyond the soundscape. For, much like the practice of soundscape composition,

these mediated sound materials are rarely employed for their sonic characteristics alone but also for their associative qualities, emphasizing the means by which sound artists may graft meaning and significance onto that which under other circumstances may be heard as systems interference or noise.

Banks' *National Grid* project (1997 – present) is a case in point, being based on the interception (via VLF receivers) and powerful amplification of a low, immersive drone generated by the 50Hz current of mains electricity, either from the local ambient power grid or directly from transformers and live mains cables within the space. Given that its source is the national distribution of AC current, the resultant soundworld exhibits an almost constant uniformity of pitch. This challenges the notion of noise as being often related to chaotic frequency distribution, whilst smoothing the transition towards its appropriation and appreciation as a musical utterance, simultaneously referencing the primordial nature of the drone in a diverse number of contemporary and global musics. This work has been presented in variety of locations and contexts, with the same principal setup being used as the basis for installations as well as concert or DJ performances. Banks' project thus displays not only a mobility of concept, but also alludes to the

fact that our experience, perceptions and the sociological resonance of strident sub-bass audio frequencies may be very different, depending on whether we find ourselves in a gallery or club context.

A similar contextual mobility, together with the ubiquity of potential ‘sound’ sources within electromagnetic urban space informs Christina Kubisch’s series of works entitled *Electrical Walks* (2003 – present). These works represent the latest evolutionary stage in the development of the electro-magnetic induction systems that Kubisch has used in a large number of sound installations since the 1970s. Each participant is equipped with custom-adapted wireless headphones, fitted with magnetic coils, together with a map of an urban area, marked with sources of electro-magnetic radiation that produce interesting sonic by-products. Thus an active exploration of the urban environment is encouraged: a soundwalk, that substitutes acoustic sounds for their otherwise hidden electro-magnetic counterparts, a sonification of continuously emanating radiation from numerous everyday sources and a guide or score for the performance of a structured intervention into the mediated soundscape.

There is also a subtle subversion here of the widespread urban practice

of the substitution of electronic music for everyday acoustic sounds which is common to users of personal stereos, iPods and portable music devices across the planet. Kubisch imbues this practice with a prominent ‘live electronic’ quality which, rather than shielding us from our immediate environment, arguably offers us a more profound and pervasive connection with it.

Mobile devices, principally the mobile phone, were used as the primary listening means for London-based architect and interactive artist Usman Haque’s open air performance/installation *Sky Ear* (2004) which consisted of a vast, luminescent cloud of 1000 helium balloons, laced with gradually fluctuating clusters of LEDs controlled by the output of EM sensors, constantly reacting to the electro-magnetic topography of the sky through which the work passed, as it rose to the extent of its moorings at a height of around 100 metres. Suspended within the cloud were also a series of mobile phones that the audience could call to sample the sonified EM activity, which in turn reacted to the extensive mobile phone usage within the immediate vicinity.

Quoting the designer and media theorist Anthony Dunne (Dunne,

2004:171), Haque refers to the electromagnetic space through which his work drifts as *Hertzian space*, which his work renders:

“physical and nonvirtual. It consists of a ghostly poetic ecology that exists just beyond our familiar perceptual limits. The universe is the oldest radio in the world. Rather than being pervasive globally, urban locations in particular have a diverse and vibrant Hertzian culture.”
(Usman Haque in Bullivant, L.(ed.) 2005: 10)

Once manifested within the acoustic domain, the electro-magnetic soundscape begins to take on an apparently similar physicality and immediacy that may more easily be correlated with natural acoustic phenomena. This may be symptomatic of the conditions found in urban environments, which function through increasingly complex interrelations of the natural and the technological, such that a robust interconnectedness between these two spheres of acoustic experience might be proposed. As Christina Kubisch explains:

“For me, silence and technology, electronic music and natural sounds are connected. All my work is somehow based on these apparent opposites. I try to integrate them instead of depicting them as a necessary choice between black and white. People who walk around in my installations based on magnetic induction in the open air, listen much more to the ‘real’ sounds after having taken off the headphones.”
(Kubisch in Collins and d’Escriván (eds.), 2007: 192)

Such interconnectedness was at the heart of the conception of *The Earth’s*

4.5 Billion Electronic Music Composition installation, where mediated EM sonic components and recordings of natural thunder (two physically differentiated acoustical outcomes derived from the same natural phenomenon) shared the same space. The one harnessed through the mediation of radio technology, the other captured through the mediation of sound recording technology, both fused and presented through the unifying element of the loudspeaker.

The electromagnetic sounds were also essential for the functioning of the work on the conceptual level, as they represented and alluded to the physical atmospheric and astronomical phenomena to which it made reference. Once this connection had been established with this first installation work, it was sustained throughout the other installations, albeit with the substitution of electromagnetic sound with that resulting from cosmological and astrophysical data sonifications. Thus, regarding the sonic material explored within the practical projects documented here, one can trace a notional continuum from acoustic space to electro-magnetic space to data space.

1.6 Sound and Artistic Space

A number of factors influenced the decision to finally move away from more traditional forms of musical presentation towards the practice of sound installation. These included the desire to offer an audience expanded spatial parameters in which to move around and inside the work, together with extended time frames within which to explore sonic experience. In many ways the intention was to offer that which Bernd Shultz has referred to as “a music with no defined beginning or previously defined end, which enters into a new fusion with visual phenomena and wants nothing more than to place realms of experience at the disposal of the participant” (Shultz, 2002:16).

Each of the installation works were intended to be monumental in scale, as a means of audience engagement and also as a statement of theatricality, especially given the cosmological or universal themes that the works explore. The operation of concepts relating to sound in artistic space differs for each of the artworks. These range from strongly delineated areas for interaction and the audition of resultant sonic material (e.g. the steel cubes in *The Earth's 4.5 Billion Year Old Electronic Music Composition*) to the sonic energising and resonance of the gallery space in *The Heliosonic Resonator*. Spatial considerations (specifically reactions to and memories of, sonic

experience in urban space) also formed the basis for the *Stockholm Sound Sanctuaries* project.

To the two main concepts of spatial movement of the audience and extended temporal durations, we can also add further considerations such as the ways in which spatial arrangements governed the deployment of interactive function within the works, together with the differentiated approaches to sound diffusion utilised. These more specific questions of technical functionality and realisation were aligned, in practice, to aesthetic notions that aimed to be somewhat critical of the overt use of mainstream technologies (e.g. many computer or screen-based applications) within gallery spaces, and the way that standardized, commercial interfaces can definitively influence audience praxis, reception and interactive potential.

These issues are outlined below, together with contextual and theoretical examples, although the consideration of these points was pivotal to the realisation of this project and as such, the discussion was carried over into the creation of the works themselves.

1.6.1 Spatial, Temporal and Corporeal Aspects

One of the key differences between the modes of presentation employed in sound installation practice and more typical concert performance is that of the perambulating audience. This dynamic situation allows individual audience members the freedom to investigate and apprehend the artwork from a large number of possible perspectives, and to actively investigate perceptual changes by the very act of moving around inside the presentation space. As the Australian sound artist and theoretician Ros Bandt has commented:

“The listener/perceiver observes the artwork from a particular location, a point in space which affects all aspects of the sensory perception of the work. Acoustically it shapes the way events are heard and retained. If the listener moves around, the pathways chosen further shape the perception of the work. From the point of view of location, each perceiver has a unique experience of the work which cannot be duplicated. Sight and sound lines result from the fixed or moving point of the viewer/auditor in relation to the artwork. (Bandt, 2001: 12)

In the development of sound installations, one is concerned with the creation of dynamic situations that are open to a large number of potential readings and experiential possibilities. The individual outcomes of which are dependent on how an audience member chooses to approach the work and the decisions they make with regard to physical movement and orientation during their experience of it. If, as Bandt suggests, the perception and overall experience of a work is likely to be highly differentiated for each participant,

an important guiding principle concerning spatial and sonic arrangements within a work is the definition of the parameters of the audience experience. However, this is not achieved in any fixed sense, as in the terms of a traditional musical composition where sound objects and events are placed in predetermined temporal relationships for an idealised (often stationary) audience. Rather, the basic structure and operational conditions of a dynamic system are defined, the artistic experience of which is only achieved at the moment of audience encounter and is somewhat different for each instance of encounter. This is especially true for works that function on the basis of interaction, whereby audience movement (or other forms of agency) have an impact on the output or behaviour of the system.

Something of the temporal condition of music remains however and definitively effects an audience's spatial experience, albeit through time frames that are often greatly expanded than those practicable within concert hall presentation. As Austrian sound artist Bernhard Leitner has stated:

“The fundamental phenomenon of sound is its development in time. Architecture is basically static, time is introduced through changes in daylight, periods of different intensity of noise and above all through the movement of people. Space is developed gradually in time. But it is not a space, it is a constant sequence of spaces.” (Leitner, 1998: 37)

Here Leitner succinctly conjoins the elements of audience movement and temporal duration mentioned above, whilst highlighting the constant mutability of our perceptions of architectural space through the interplay of dynamic factors.

Leitner's own artistic development over nearly four decades has encompassed a far reaching exploration of dynamic sound presentation, through works that deal with the sonic articulation of space and its transformative effect on an audience's experience of spatial form. Early experiments in the 1970s involved the creation of large-scale wooden superstructures upon which equidistantly – mounted loudspeakers facilitated the definition of space with sound traveling through straight lines, spatial arcs and increasingly more complex intersecting figures. Spatial perception was also enhanced by the application of various musical parameters, such as controlling the relative speeds of movement of the sonic formations, together with changes of rhythm, tempo or timbre within the sound material itself.

Having created a series of works in which sound propagates around, above and underneath the audience, Leitner began to formalise an approach based around the corporeal nature of our sonic experience, which not only

encompasses the ears, but the entire body:

“ It became clear to me rather quickly that I hear a sound that goes under me with the soles of my feet, that I hear with the skull cap, that – and this was really decisive – that the boundaries of sound space can also go through the body, so that the body is not something standing vis-à-vis or on the side of the whole concept. It is in it and the boundary can pass through the body. Spaces can extend into the body. This is one of the most interesting aspects of my work with acoustics, that entirely new concepts of space open up through extended hearing, through bodily hearing.” (Leitner in Schultz, 2002: 83)

By expanding our conceptions of sonic space beyond the threshold of the body we not only emphasise the intimate relationship we have to sound and differing modes of sonic experience, but also the fact that sound is a key attribute of spatial awareness. Artistic strategies developed from these concerns can give rise to highly effective approaches to the siting of audience members within a sound installation work and also the placement of the experience of such a work within an audience member's physiognomy.

With regard to the installation works in the practical portfolio, these aspects are most fully explored with *The Heliosonic Resonator*, wherein low frequency sound generated by seismic disturbances in the Sun's interior is experienced as corporeal vibration, most notably in the voice box and the

chest cavity. In this instance, the ‘resonator’ is not just the work, but the human body itself (see Chapter 6).

Further examples of artistic conceptions of sonic space can be found in the work of Robin Minard, whose practice can be seen as doubly relevant in this context as he is a composer of acoustic and electro-acoustic music who, from the mid-1980s onwards, began to focus on sound installations. His work involves the site-specific deployment of sound within public environments or existing architectural spaces (often beyond the traditional gallery space) in such a way that intimate and subtle dialogues emerge between the space, the sound materials presented and the audience. Furthermore, concepts of the environment (both natural and urban) are often evoked and explored. These are manifested through the choice of processes and sound sources used, the existence of the works as ambient interventions within everyday experience and the physical production values and visual aspects of the installations.

Minard characterises his approaches to installation development in terms of the concepts of sonic *conditioning* and *articulation* of space (Minard, 1999: 75). Spatial conditioning is understood to delineate the

creation of quasi-static or perceptively uniform sonic states that exhibit very little (or otherwise slow moving) development in the temporal domain and are intended as low-level interventions within an existing sonic environment. These states may also contain specific masking functions, sublimating certain frequencies or more strident sonic occurrences. Spatial articulation, on the other hand, relates to spatial diffusion: the dynamic movement of sound or the localisation of certain frequencies or sonic events.

A work such as *Klangstille* (1995) can be thought of as a demonstration of Minard's concept of spatial conditioning and involved attaching several hundred piezo loudspeakers to the windows of the Mathematical Library of the Technical University, Berlin. Similar to an adjacent work, *Weather Station* (1995), the work utilised the MAX programming environment to facilitate the control of MIDI audio elements by a series of sensors fitted to the exterior of the building and monitoring changes in light and temperature. This data was then mapped across as a means of controlling material characteristics such as dynamic level, pitch, repetition or timbre. Given the specific requirements of presentation within a library context the "sounds of the installation were designed to lightly colour the silence of the existing space and to create a calm environment conducive to concentration and

study.” (Minard, 1999:107). This work can also be seen to have correspondences with the works discussed in the above section on sonification, especially those works that explore sounds created or controlled by meteorological data.

Stationen (1992) developed for installation at various locations in the Parochial Church in Berlin (at the time occupied by the Singuhr sound art gallery) demonstrates aspects of the concept of spatial articulation, with specific sounds derived from and deployed within certain parts of the existing architecture of the building. Microphones mounted on the exterior of the bell tower picked up ambient sound from the immediate vicinity and these were overlaid in the church’s interior (especially within the bell tower itself) with sine waves which together formed an extended chord constituted of natural harmonics which rose in pitch as one ascended to the different levels on the staircase.

1.6.2 Analogues of Sound Processing Technologies in Physical Space

The approach to sound spatialisation and the specific processing techniques to which it may be subjected can also be built into an installation structure, becoming an intrinsic part of the physical form and function of the artwork.

This is the case with the practical works discussed here, especially those where the resultant sound is achieved through the playback of pre-recorded audio via loudspeakers conjoined with the physical conditions to which this material is subjected due to facets of the installation's construction, the behaviour of its systems or the intervention of the audience. Thus, the brass horn of the antique gramophone in *The Cosmic Phonograph* (see Chapter 4) or the dynamic aqueous-acoustic tuning pistons in *The Hydro-Acoustic Big Bang Filter* (see Chapter 3) are two examples of physical structure having a definitive effect on sonic result.

This last example can also be seen as an instance of the creation of a physical analogue of a sound processing technique commonly associated with music technology, in this case a series of sliding band pass filters, as a principle factor of installation design. Another similar case is *The Heliosonic Resonator*, where the large-scale di-polar radiator (effectively a loudspeaker without a cabinet) forms the basic structural concept (see Chapter 6).

Sonic processing in these works does not happen inside software or outboard equipment, but is something an audience can (through the real-time operation of the installations) physically experience and experiment with in

a tactile, corporeal sense.

1.6.3 The Staging of Technological Space

A further consideration, of equal importance to these pieces as the means of sound propagation, is the manner by which technological equipment, cabling, loudspeakers and other components are presented in the physical/visual sphere. Thought, care, attention to detail, together with high production values in this regard can add immensely to the integrity of a work, effectively foregrounding the artistic intentions themselves, rather than drawing attention to how their presentation is facilitated.

We may describe these aspects as *the staging of technological space*, with sound and media artists adopting numerous potential standpoints in relation to these issues. For some, such considerations are central to the ways that a work is conceived, presented and received. For others these matters have a fairly low status with a scant amount of curatorial or technical production attention at times in evidence. Whatever the approach, decisions taken in this area always have some level of aesthetic implications.

Additional examples from Robin Minard's oeuvre can demonstrate how the extensive technological requirements within a sound installation space can be integrated to aesthetic advantage. In works such as the various versions of *Silent Music* (1994 –) or *Klangstille* (1995), mentioned above, the arranging of several hundred small piezo loudspeakers and their associated cabling are re-imagined and fashioned into seemingly organic, botanical or plant-like structures. These visual gestures at once defuse the technological nature of the space (whether installed in a gallery or especially in an exterior or natural setting) and also find resonance with the sound material utilised. As Minard explains with reference to *Silent Music*:

“Just as this aural experience presents a mixture of natural and synthetic elements, so does the visual. Although the work is composed solely of loudspeakers and loudspeaker wires these are placed in a manner that suggests life, growth and movement towards light. This work inhabits the space in much the same way as would a living organism. At the same time it projects the observer back and forth between the perception of the familiar and the unfamiliar: between that which we perceive as being natural and alive and that which we perceive as being technical and artificial.” (Minard, 1998: 105).

Careful consideration of how technological equipment is displayed and deployed can give rise to such complex associative dialogues. By sublimating, or in other ways staging the physical presence of technology an artist can delicately construct and influence the ways an audience will

approach an installation, the manner of address and how their actual presence is implicated within the work.

Otherwise, overt technological presentation can definitively condition how a work is perceived. Prominent placement of loudspeakers, PCs, monitors, plasma or projection screens can say to an audience: “you are having a technological experience” and thus encourage them to engage with the work through a limited number of receptive strategies or received behaviours.

The nature of the influence that given technologies have on our reception of art that employs them is suggested by what media theorists Jay David Boulter and Richard Grussin have termed *remediation* (applied to emergent digital media), through which they have stated that:

“Like all media since the Renaissance – in particular perspective painting, photography, film and television – new digital media oscillate between immediacy and hypermediacy, between transparency and opacity. [...] The process of remediation makes us aware that all media are at once a “play of signs” [...]. At the same time this process insists on the real effective presence of media within our culture.” (Boulter and Grussin, 2002: 19)

For Boulter and Grussin media technology can display tendencies towards

transparent *immediacy*, understood as giving rise to an experience unencumbered by technological presence or interfacial characteristics. Conversely, *hypermediacy* denotes the strident presence of technology, thus becoming a large determining factor in presentational concepts and situation and likewise audience perception and reception. An artist can thus deliberately place their engagement with these issues of technological placement on an axis between the subliminal and the strident, with this potentially becoming an important aspect of the communicational strategies of the work.

The portfolio installation works were created with the aim of sublimating the presence of many of the technological aspects used. Loudspeaker placement, for example, is hidden or otherwise obscured. Likewise cabling and most other electronic components are concealed within the installation structure. Counterbalancing this preference for veiled technological presences, certain artefacts (e.g. the antique technologies, radios and gramophones – see section 1.8) are deliberately emphasised.

The mode of operation with regard to the interfaces of the works is also (at first) non-explicit, engendering an audience member to explore how one

should interact with the work. This interplay between the subliminal and the visible is key to the construction of the sound spaces that embody these works. Sound propagates through spaces with few obvious technological signifiers, with the aim of allowing focus to remain on the artistic content and encouraging an audience to approach the work on its own (and their own) terms.

1.7 Interactive Strategies and the Role of the InterActor

“How the audience is engaged and the extent of involvement are critical issues in the era of that fashionable buzzword, interactivity. The following two questions need to be constantly asked and clearly answered in relation to specific works: What type of interactivity is it? What exactly is it the audience is being asked to do? The meaning of the word interactivity has narrowed since its use in screen-based multi-media works which rarely achieve the complexity of sound sculptural artworks embracing three dimensional form and time.” (Bandt, 2001: 79).

The considerations associated with defining the parameters and operations of a sound installation space, thereby implying the audience member’s physical presence within a work, are heightened and brought into sharper focus once concepts of interaction are introduced. For an interactive installation not only implies the audience’s presence, but seeks at some level to establish a reciprocal connection, inviting some form of action or response as a means

of completing the artwork. Thus, some form of corporeal engagement is a critical factor to the artistic experience.

In this section I offer an overview of the interactive functions of the installation projects described herein, together with discussing a number of contextual and theoretical examples that may inform our understanding of them. Finally, I also define the concept of the InterActor, a term which originates with Interactive Agents and is used to define the audience member simultaneously as a listener/viewer/performer, facilitating a means of conceptualising their relationship and role within the work.

Ros Bandt is accurate when she points to the narrowing of scope with regards to terms such as ‘interactive’ or ‘interactivity’ and their common usage to denote specifically computer or screen-based technologies. It should therefore be stated at the outset that the practical installations created as part of this research completely eschew the use of PC or screen-based applications in favour of solutions created from discrete and proprietary electronics. Indeed, as media theorist Lev Manovich has commented regarding the tautology that exists between computer-based technologies and concepts of interactivity: “to call computer media ‘interactive’ is

meaningless – it simply means stating the most basic fact about computers.”

(Manovich, 2001:55)

The reasons for rejecting the computer with respect to the development of the installation works are manifold and are explored throughout this thesis. Firstly, this decision was due to what I described previously as the means by which technological space is staged. The placing of a computer (or any such peripheral technologies) within an artistic space can signify too strongly the idea of a ‘technological experience’, an association that may be totally extraneous to the aims of a work (the medium *isn’t* always the message).

Secondly, by simplifying the design of a system down to its most essential components one forgoes the requirement for vast amounts of unused computational power, thus in many ways safeguarding the stability of the system – an essential factor in the continuous apprehension of a system as a viable artwork. Thirdly the aim was to approach that which Bandt characterises above as ‘three-dimensional’ experience, meaning that the interactive and technological functionality should be embedded within the work and the installation space, offering a resultant experience that we might

describe as immersive. Furthermore, such a position postulates that one of the best ways to immerse an audience within a work is perhaps not to ask them to engage with cumbersome technologies in the creation of a virtual space (e.g. Virtual Reality), but to actually immerse them in ‘real’ space, as constructed and presented through the design of the installation itself.

1.7.2 Modes of Interaction

We may broadly define the species of interactivity utilised within the installation works under the term *responsive*. In the present context, this term can be understood as denoting a situation whereby the embedded interactive system, encompassing an array of sensors, responds to audience members (or InterActors) within a certain spatial proximity to the installation. This enables the InterActor to trigger audio playback, together with other installation-specific elements, such as integral lighting systems and other processes that have a direct, physical effect on the sound material.

The interactive sound artist Garth Paine cites Bert Bongers in stating that many interactive systems can be described as reactive “due to the

absence of cognition”⁵ (Paine, 2002: 297). Bongers goes on to suggest that “The level of interactivity should challenge and engage the audience, but in practice ranges from straight-forward reactive to confusingly over-interactive” (Bongers, 2000:49). However, there would seem to be something of a trend emerging which favours interactive installations of the more ‘straight-forward reactive kind’, as a means of initiating and prolonging audience engagement, as interactive video artist Jim Campbell explains:

“In creating interactive video art work, my goal has been to move away from the conventional computer screen “button pushing” interface and instead to move towards creating works that have a more intuitive level of interaction. Making a distinction between a work that is controllable and a work that is responsive. I have tried to create installations that are less about a viewer dominating a work, and more about viewers participating in the developing personality of a work.” (Campbell, 2003)

There is a marked shift away here from the concept of audience control towards a more subtle form of interaction. Here again we also find this kind of work characterised as ‘responsive’, a term Paine likewise uses to describe a number of his interactive sound installation works (Paine, 2004) (mentioned below).

⁵ One must assume here that Paine is referring to a lack of cognition in the system, rather than in the audience member.

The term has also been employed by architectural curator, critic and theorist Lucy Bullivant to designate what she describes as *responsive environments*⁶ (Bullivant, 2006) as a means of conceptualising developments that she has traced in architecture and art of the 1990s and 2000s, where hybrid practices have created spaces that respond and interact with the people within them, be they within a museum or gallery context, or within other types of public or domesticated spaces. Bullivant explores a number of examples such as interactive building skins, intelligent architectural spaces and museum and visitor attractions, many of which are profiled by subtle and innovative means of interaction which respond to audience presence, movement, agency and many other factors.

With regard to the important factor of how utilising interactive systems impacts on how one approaches the deployment of sonic material within a work (especially regarding the temporal domain), we may return briefly to

⁶ The term *responsive environment* may have a slightly longer pedigree than is suggested here, as the interactive art pioneer Myron Krueger has used the term since the 1970s to denote his specific practice of creating artistic situations that, through the use of computer technology, create interactive experiences without encumbering physical interfaces (Krueger, 1991). His example also forms an important forerunner of the interactive works discussed in this thesis.

Bert Bongers who states that:

“In the case of an installation work [...] one could say that the artist communicates to the audience *displaced in time*. [...] The artist's actions, intentions and ideas are built [into] the system.” (Bongers, 2000: 48).

In many ways it was a theoretical position such as this that finally broke the creative deadlock that was at the basis of my dissatisfaction with instrumental and traditional electro-acoustic composition techniques (described above) and their integral notions of fixity with regard to temporal relationships. Within an interactive sound practice the composer specifies the sounds, together with their means of diffusion and specifies (to a large degree) the structural, visual and environmental attributes of the space through which they are to be experienced. The composer also creates the conceptual framework that pertains to the sonic material and again, how this is to be made physically manifest in the exhibition space. Finally, the composer specifies the nature and operative functionality of the interactive dimensions of the work, defining the means of audience engagement. Once the development and construction work is completed, the composer stands back and invites the audience to take an essential role in the completion of the work.

1.7.3 Specific Interactive Characteristics of the Installation Works

The common interactive attributes of the installation works within the practical portfolio, which informed their design and construction, can be outlined as follows:

- Personal, direct attribution of InterActor effect on the system, coupled with an immediate, identifiable response that should be reliable, but non-uniform.
- Elements of small-scale InterActor collaboration, due to observing and interacting with other audience members.
- The interface should be non-explicit and non-intuitive initially (with many technological signifiers sublimated), thereby endowing an element of mystery in terms of the manner of operation.

However, once the operative method is discovered, it is then obvious, with no further learning involved and the InterActor can choose to continue experimenting with the work.

All of these characteristics were consciously designed into the interfaces and installation-specific details are given in each of the chapters that discuss the individual works (see Chapters 2 – 6).

1.7.4 Further Contextual Examples

Garth Paine's *MAP2* (1999) installation translates a number of parameters derived from audience movement into sound by using video sensing technology to activate a series of real-time synthesis algorithms in order to create real-time musical responses controlled by the audience. The gallery environment is divided into four sections, with each section responding to the individuals within it independently and asynchronously to all the others. Paine describes this work as “ a virtual musical instrument using the movement of those within it to compose music in realtime.” (Paine, 2004). Although exhibiting a species of interaction that differs somewhat from that discussed above, Paine offers an extremely apposite consideration of the initiation and rapid development of audience engagement with such environmental situations:

“I posit that when walking into an interactive, immersive environment, the first moment of interaction is a profoundly intuitive, corporeal one.

A relationship is established as soon as one notes that the environment changed on your entrance. That change is an invitation to explore, and an acknowledgement that you are immediately a part of an intimate causal loop. The patterns of relationship in an interactive, immersive environment are made explicit and coherent through many iterations of the closed causal loop.” (Paine, 2007)

Paine references here the key elements of play, invited experimentation and the adaptation and modification of approach through feedback that characterises possible audience member behaviours when confronted with an unfamiliar interface in an artistic situation. Each of the examples mentioned below approach these kinds of concepts of engagement. All are large scale installation works and exhibit modes of interaction that invite a process of experimentation, especially through the utilisation of non-standard (or otherwise sublimated and embedded) interfaces.

The German media artist and former architect Christian Moeller has, since the mid-1990s, created a number of installations that have explored the audience control of audio-visual elements with highly intuitive and straightforward interactive principles. *Audio Grove* (1997) and its companion piece *On Air* (2003) (Moeller, 2004) both consist of a large number of 5.5 metre vertical steel poles (56 in the case of *Audio Grove* which rise from a large circular wooden platform. Each pole is touch-

sensitive and when touched by a participant a single synthetic pitch event is emitted from the audio system designed by the composer Ludger Brümmer. The simultaneous touch of two poles can cause pitch shifting in the sound material or a range of other manipulations of the audio elements that are also adapted by parameters such as the number of participants in the space at a given time. The lighting system, which consists of 25 sources placed high above the work in the ceiling of a vast atrium space, also responds to the same mode of audience activity, triggering a constantly shifting palette of lighting states which create a dynamic interplay of light cast through the steel poles on the floor of the space. *On Air* presents a similar physical situation, with 44 poles, each representing a broadcast audio signal from different countries around the world, received in real-time via satellite. The act of touching a pole allowed participants to singly, or in any combination, sample impromptu collages of diverse transmission material.

Both of these works represent elegant solutions to the challenges of how to engage potentially large-numbers of people within a space whilst still maintaining a situation where participants can directly experience and identify the results of their involvement.

1.7.5 The Science Museum Effect

Moeller's *Insound Out* (2001), again created in collaboration with Brümmer, was commissioned by the London Science Museum. The work, which offers a different approach to the physicality of sonic experience, was presented to the audience as a corporeal proposition and encompassed two vibrating steel grilles recessed into the gallery floor, upon which their physical movements were tracked by a video camera, triggering highly-directional plexiglass speaker domes to project sound directly into the participant's body.

Simultaneously, Robin Rimbaud's *Sound Curtains* (2000), situated directly in front of the public conveniences of the museum's newly-opened Wellcome Wing recessed a number of concealed sensors into the ceiling of the entrance hall. These registered human movement, thus triggering audio playback of a range of sounds broadly pertaining to science or scientific enquiry. Shortly before unveiling the work, Rimbaud explained his concept:

“What it will throw down to you randomly will be recordings of science, the invisible sounds of science. Sounds inside the human body, the blood rushing, bones cracking and creaking, through to sounds inside computers, PlayStations, electricity, power stations, the sun - the language that science speaks to itself that we never hear. There are two million people visiting this place every year, I don't want it to be hands-on or to wear headphones, because that immediately limits it. Then it becomes a physical object, which people have to queue up for, and which can break. The idea was that people in wheelchairs are also able

to engage with it - it's a very open access idea.” (Robin Rimbaud in Young, 1999)

The fact that these two examples were installed at this particular institution is notable in this context, as one of the primary design principles often discussed during the early concept phases of this project’s practical works were a set of ideas that coalesced under the term *The Science Museum Effect*. This concept referenced the way in which certain basic principles suggestive of the functionality of interactive exhibits, displays or visitor attractions at museums of science and technology can be used as the basis for the interface design of artworks. These can include the fostering of a certain level of accessibility, such that a work may potentially appeal to a diverse audience that are encouraged to explore an exhibit’s interactive potential. To this we can also add the facet of learning through play and the manifestation of possibly complex scientific concepts in a manner designed to attract and hold the attention, rewarding repeated usage or short-term extended engagement (similar to Paine’s *causal loop* mentioned above). This facet of the design approach seemed particularly relevant given the source material and conceptual orientation of the works. Furthermore, as Bullivant has observed (Bullivant, 2007), institutions of science or natural and cultural history increasingly choose to engage with contemporary art,

especially of an interactive nature (as the previous two works exemplify).

This seems to suggest that the development of ideas such as these on the creation of art is by no means a one way street.

A final example originating in the public museum sector is the work *Volume* (2006) commissioned by Sony PlayStation and the Victoria and Albert Museum and realised by the new media design collective United Visual Artists (UVA). Self-described as a “luminous responsive installation”⁷ that consists of forty-six 2.5 metre monoliths, each fitted with display units created from uniform, rectangular matrices of LEDs. Each monolith was also fitted with a loudspeaker and represented one of 46 independent audio channels with music and sound material specially-created by the band Massive Attack. The work was based around a digital time-lapse system, situated above the grid, which frequently took pictures and compared each successive frame to a digital map of the monoliths held in computer memory. It was thus able to calculate the changing position of participants with respect to the monoliths and use this data to control the

⁷ According to the descriptive signage for the work displayed in its vicinity on the riverside concourse outside The Royal Festival Hall, London in Summer 2008. Incidentally, when I first visited this work at this location it was not functioning and two UVA operatives were feverishly working at laptops in an attempt to re-boot.

dynamic level of the audio channels according to participant proximity. If a participant stood still for a short length of time they would become effectively invisible to the system and not have any effect until they decided to move again.

Halfway between the virtual and real space, *Volume*, appeared to exhibit a number of different interactive modes, which occurred in sequence. Each of these differed in terms of visual and sound material as well as functionality, exhibiting shifting forms of interaction from the highly intuitive and direct to the counter-intuitive and enigmatic.

1.7.6 The Role of the InterActor

The term *InterActor* was created by Interactive Agents to describe the role of an audience member in relation to one of our interactive sound exhibits. The intention of this term is to cast the audience member simultaneously as a listener/viewer/performer, as it is through these three roles, and their interchangeable nature, that the participant experiences and impacts upon the artwork. As explored in the individual work chapters, this subtle re-casting of intention towards the audience is also consequent on the process of creation, as well as the receptive strategies of the practical works.

The notion of interaction can be directly equated with that of the *performative*, and it is this assertion that is at the foundation of the concept of the InterActor. After briefly defining these terms as a way of fostering an appreciation of how they may be combined, we will extend this enquiry further by approaching the idea that this kind of interactive gallery practice can be seen as an extension of certain theories pertaining to performance arts practice.

The use of the term ‘performative’ is made problematic by the fact that there seems to be no consensus among academics as to a general definition of the word. It is however in common usage in relation to a number of disciplines. The American director and academic Richard Schechner comments that both the theatre and certain branches of modern philosophy, such as post-structuralism make use of the term, although with differing meanings. For our purposes here we shall consider the following definition offered by Schechner himself:

“Performativity is everywhere – in daily behaviour, in the professions, on the internet and media, in the arts, and in language. It is a term very hard to pin down. The words “performative” and “performativity” have a wide range of meanings. Sometimes these words are used precisely. But more often they are used loosely to indicate something that is “like a performance” without actually being a performance in the orthodox or formal sense.” (Schechner, 2002: 110).

This definition of the performative as describing a situation that is “like a performance” is perhaps most useful to us in the current discussion, because in experiencing a multi-sensory interactive environment such as those represented in the practical portfolio, the InterActor will find themselves in a situation where they have to “act”. They have to be active in some manner through physical gesture, or presence or movement, to get the systems within the artwork to respond, and thereby complete the artistic experience.

However, one of the main differences between this mode of performance and more orthodox species of theatrical performance is in what we might describe as *characterisation*. That is to say that an InterActor, is an actor without traditional theatrical conceits. An InterActor always plays themselves in the given artistic situation, and their everyday repertoire of behaviours is thus coloured and adapted to the situation. This adaption can take a number of forms, and can be precipitated by watching the actions of other InterActors in the same space, or by the reactions and feedback of the interactive systems in the artwork.

To highlight the meta-nature of the disposition of the InterActor within

this theoretical artistic scheme, one must remember that an InterActor will also display some of the functions of a receptor, of a listener and a viewer, attributes more commonly found in the disposition of a traditional audience member. The combination of these other attributes will also have an effect on the more active aspects of their relationship to the artwork.

If we briefly contrast this situation with a more traditional receptive audience situation it should help to throw the distinction between the two states into sharper relief. Brian O'Doherty in his influential study of the praxis of presentation and reception in the art gallery environment *Inside the White Cube: The Ideology of the Gallery Space*, describes the relationship between gallery and spectator thus:

“Unshadowed, white, clean and artificial – the space is devoted to the technology of aesthetics. Works of art are mounted, hung, scattered for study. Their ungrubby surfaces are untouched by time and its vicissitudes. Art exists in a kind of eternity of display, and though there is lots of ‘period’ (late modern), there is no time. This eternity gives the gallery a limbo-like status; one has to have died already to be there. Indeed the presence of that odd piece of furniture, your own body, seems superfluous, an intrusion. The space offers the thought that while the eyes and minds are welcome, space occupying bodies are not – or are tolerated only as kinaesthetic mannequins for further study. (O'Doherty, 1991: 15).

There is quite obviously only a narrow band of performative options open to this kind of spectator within the confines of the idealised white cube. Similar

can be said of the confined audience member in a number of the other arts.

By contrast, the ideal InterActor is constituted as eyes, ears, body and mind:

a spectator/participant who performs an integral part of the work.

1.8 Nostalgia and Retro-futurism

“Zoëtropes, kinetoscopes, stereoscopes, phonographs, pinball machines, fortune-telling machines, periscopes and guns, household appliances, vintage television sets, even obsolete computer displays and videogames – the whole repertoire of old tech, rapidly increasing due to technological change, seems to have invaded the art gallery” (Huhtamo, E. in Moser, M.A. and MacLeod, D. (eds.), 1996:233)

The appropriation and re-deployment of obsolete, antique or superannuated sound technologies is another common factor which represents a further important point of intersection for all of the practical projects. Similar to many of the concepts discussed in this opening chapter, this approach has its origin within the first installation project *The Earth's 4.5 Billion Year Old Electronic Music Composition* (2002) and the decision to use a 1951 Marconi valve radio as the only overtly visible technological component. This was then followed with the centrepiece of *The Cosmic Phonograph* (2004), which was an antique HMV gramophone (complete with moulded

resin Nipper) and the re-fashioning of a series of 1930s-1950s floor-standing radios as suggestion boxes that were installed in various public museums and art spaces, collecting public nominations for the *Stockholm Sound Sanctuaries* project (2004-2005).

There is a facet to these works that is definitely an instance of that which the Finnish media theorist Erkki Huhtamo has termed *media archaeology* (Huhtamo, 1996), the fascination for exhuming machines from the technological past and re-contextualising them in the present. Huhtamo has also commented that this practice can be thought of as a kind of virtual time travel, and this may indeed be part of the appeal for integrating such objects into one's work. In the case of the works mentioned above, however, the use of these objects simultaneously was intended to represent a subtle comment on the way we objectify and present technology, especially in a gallery context, and a comment on how new technologies are often displayed as integral features of media artworks of all kinds. These notions were discussed previously in this chapter with regard to what I defined as the staging of technological space and the way in which audience experience and reception can be conditioned by overt presentation of technological elements.

With the installation works mentioned above the situation is characterised by all of the technology utilised (playback devices, loudspeakers, outboard processing and cables) being hidden, or at least sublimated. The most prominent evidence that one is having an experience involving technology is conveyed by the presence of the old technology, as this is the only technology to which the attention of the InterActor is purposefully drawn. The reason for doing this (as discussed at various junctures throughout this text) is not to overstate the technological nature of the works and that perhaps, when the presence of technology is visually minimised, one can feel that the experience is more organic, or even, more mysterious⁸. There is definitely an implication of the organic when presenting an ‘ancient’ technological artifact in a space which is otherwise rigged with veiled newer technologies. There is an organic feel to these artefacts in any case, especially if one considers them in terms of the contemporary speed of progress and the resultant stratification of technological history.

⁸ In any case, the integrity of the staging of the space according to the conceptual bases of each installation work is maintained. To use a filmic analogy, the intrusion of any overtly technological signifiers in these works would be as incongruous as the inadvertent appearance of a boom microphone in the top of a shot in an 18th century costume drama. Production values generally prevent this kind of occurrence.

These artifacts may also evoke feelings of technological nostalgia in an audience, an emotion that can be thought of as particularly slippery and subjective, adding another layer of differentiated experience potential on the part of the InterActor. An individual's nostalgic responses are completely personal and context-specific and there are no guarantees that these artifacts will function for an audience in quite the same manner that is intended by their presentation and positioning within an installation. For myself, the utilisation of these antique technologies may, for example, represent a slightly esoteric form of nostalgia for that which was never actually experienced first hand.

The multi-faceted resonant qualities of these objects may in fact be part of their attraction and, as Huhtamo has suggested, a number of artists are increasingly exploring these ideas within their practices, with contemporary sound art being no exception. This is exemplified in the work of Christian Marclay, many of whose visual and sculptural works (created concurrently with being active as a musician and DJ) use a vast array of objects associated with the production of music or sound, from musical instruments, old loudspeakers, record players and open-reel tape recorders to manipulated

used vinyl records and record covers.

As Russell Ferguson has observed (Ferguson, 2004), the majority of Marclay's sculptural output is actually silent, thereby only referencing the idea of sound and the technological objects that are associated with its creation, storage and reproduction. Regarding this Marclay has commented:

“My pieces are silent, so that you can fill in the blank. I want people to use their memory, their own memory. Memory is our own recording device, so instead of imposing a standardised memory like a record, we have our own personal memories, which are more selective” (Marclay quoted in Ferguson, 2004:19).

Similar concepts of memory and the use of redundant audio technologies for their associative qualities, together with the way in which an object's history is in some respects inscribed upon its surface is apparent in John Wynne's installation *Fallender Ton für 207 Lautsprecher Boxen* (2004) and the subsequent *230 Unwanted Speakers* (2006), in which the titular quantity of discarded loudspeakers salvaged from the streets of cities were installed on the floor of the gallery space in a semi-circular formation, with one speaker affixed about two-thirds of the way up one of the walls, or in the case of the later work, suspended from the ceiling overhead. The sound material consisted of seven channels of steady-state sine tones, tuned to the resonant

frequency of the space and distributed throughout work. Regarding the use of the objects themselves, Wynne states that:

“it became immediately apparent that each of these rejected pieces of consumer technology had a story to tell, a history which endowed them with a kind of personality. Although it was far from my original intention, I decided to arrange the speakers in what the curator, Wolfgang Schlegel, described as ‘a field of social tension,’ which would suggest a narrative. But it also would draw attention to the personalities of the individual speaker boxes, projected through their design, the marks of use and misuse, the modifications carried out by their owners, and even their smell.” (Wynne, 2004: 42).

This kind of anthropomorphic approach once again points to the kinds of emotional charge with which these objects can be imbued, a situation that, of course, says more about individual artists and audiences than anything actually intrinsic about the objects themselves. Indeed, Philip Jeck who has used vintage vinyl and record players in live performances for many years, has also created a number of installation works involving large numbers of appropriated portable record players, such as *Off the Record* (2000) and *Vinyl Graveyard* (2003) admits to rejecting the term “nostalgia” with respect to his work for many years:

“People have always said that the records are nostalgic to me and I think I probably denied it like it was a dirty word. But actually there is, there’s something poignant about playing snatches of music. Even if people don’t actually know what the record is, there’s something about the sound that can transport you” (Philip Jeck in Bliss, 2004).

All of the kinds of resonances mentioned here pertain at some level to many of the practical works. These include the transparent Perspex back fitted to the 1950s radio in *The Earth's 4.5 Billion* so that the patina of fifty years of collected dust can be seen around the glowing valves and other components, or the three-dimensional reconstruction of the His Master's Voice logo recalled like a distant echo from any number of record labels, such that the installation has for many a pre-existing visual impact or association intended to heighten interest. This also informed the reason for using antique radios as suggestion boxes for the Stockholm project, for in these days of ubiquitous technologies in urban locations, the sight of these dormant devices can be slightly unexpected, arousing interest, in some cases enough to take part in the survey.

The deployment of these outmoded technological signifiers is also in accordance with the methods by which the installation works were created. Both in terms of their construction, involving relatively low – tech electronic components, but with high production values and also certain types of sonic associations (essentially those vaguely connected to vintage sci-fi soundtracks) which were one of the early germs of the entire project.

All of the above aspects may be said to loosely coalesce around the concept of *retro-futurism* (as mentioned above). This term is allied with a fairly unstable set of definitions strewn around the Internet, generally being attributed to Lloyd Dunn, who is said to have invented the term as the title of a small, self-published magazine in 1983⁹. It was also used more recently by the Museum of Contemporary Art, Los Angeles, as the title for an exhibition of the work of the American car designer J. Mays (creator of the new Volkswagen Beetle) (Brooke, 2002). In the present context we shall define the term as alluding to concepts of the future as it may once have been envisioned (e.g. in sci-fi media of the mid-20th century) or, paradoxically creating the future through the prism of the past.

Retro-futurism may also be used to describe certain elements of the visual aesthetics of the installation works. Many InterActors commented on the subtle visual references to sci-fi films in the design of the works (see Chapter 7), with *The Earth's 4.5 Billion Year Old Electronic Music Composition's* starkly-lit steel space frame being described as *Blade Runner-*

⁹ An example of such a definition can be found at: Retrofuturism: <http://pwp.detritus.net/in/1997/rf.html>

esque on more than one occasion and many audience members finding strong echoes of the Transporter Room from *Star Trek* in the overall scheme of *The Hydro-Acoustic Big Bang Filter*, for example.

These resonances were, of course, intentional. They also point to the way one can suggest certain conceptual considerations or lines of association without the need to resort to large amounts of descriptive text in the gallery space. One can effectively suggest the idea of “radio” by invoking a vintage radio, for example, or the idea of “science” by veiled glances towards certain larger-than-life pop cultural gestures. From this perspective, therefore, these works can be seen as an attempt at the complex interlacing of antiquated technologies and vintage science fictions with the residual sonics of science fact.

1.9 Collaboration

The concept of collaboration became a major component of the developing artistic practice associated with this research project in 2002, with the creation of the first major interactive sound installation *The Earth’s 4.5 Billion Year Old Electronic Music Composition*, a work that was constructed in collaboration with Phil Arnold and Dermot McGinley. At the time this work was viewed (in terms of the practical portfolio, which I had intended to

be exclusively electro-acoustic) as something of a side project and not the important change in direction it was to prove to be. In actual fact, when the work was shown that year at the Cybersonica festival in London, it was shown under the name Robin McGinley, a situation which, in the weeks preceding the opening, I felt was somewhat unacceptable given the fact that it was created as a group effort. It was at this time that the idea of Interactive Agents began to take shape, thus subsuming any single artistic identity within that of a group, and signifying, in all later showings that what was being presented was devised and constructed by three collaborators.

The nature of each member's contribution can vary depending on the project and is also often contingent on the stage a particular project is at in development. However, the specialism of each of the members is delineated below, thus giving an idea of the broad scope of each individual contribution.

Philip Arnold's background is within industrial engineering and he now specialises in the design, construction and installation of custom-built audio-visual systems to a range of private and public sector clients. A key element of his contribution within Interactive Agents is the conceptualisation, development and construction of the physical and structural form of the

large-scale artworks. He is also extremely adept in assessing the feasibility (and in many cases realising) the more outlandish structural concepts that the group (not least of all himself) can devise. His expertise as an audio-visual engineer means that he also originates much of the design for the bespoke audio delivery and dispersion systems that feature in all of the works.

Dermot McGinley studied electrical engineering and town planning and has nearly 30 years experience as a computer programmer and systems architect. In terms of Interactive Agents' projects he is responsible for the design and assembly of the control technologies utilised in the artworks, thus realising key aspects of interface design, which is the province of the group as a whole. It is due to his original expertise that the control systems utilised within each of these artworks are able to eschew the more standard computer applications in favour of discrete, proprietary electronics. This enables the realisation of one of the most important conceptual aspects of the installations: that they should function as machines that are constructed for one purpose, as artworks, without extraneous elements such as PCs or standardised interfaces.

My own contribution, stemming from my background as a composer and artist, has involved identifying, establishing and developing the

underlying conceptual artistic basis for each of the works, and thus the theoretical foundation upon which they were developed. In each case, the foundation has derived from the concerns of this research, and it is for this reason that this aspect of the artworks forms the primary focus of the descriptive chapters contained within this thesis. In addition, I was also primarily responsible for sourcing and preparing the audio material utilised in each work and for all aspects of resultant documentation: textual and audio-visual, either for academic purposes (essentially the basis for this thesis) or in terms of promoting and situating this artistic practice within the wider art world.

These descriptions are necessarily simplified overviews of each individual's contribution, with the balance of contributions continuously fluctuating throughout the process of creation and construction. The above paragraphs also do not account for the considerable overlap between the various areas of input mentioned. All of this further supports the requirement for a group identity as a central presentational strategy in the public exhibition of these works. Interactive Agents, the identity that was finally chosen, not only emphasises the interactive nature of the artworks themselves, but is also a playful appropriation of the concept of corporate

identity, which the group explores and exploits through its various public statements and manifestations.

The whole concept of authorship in mid-late 20th and early 21st century contemporary art has been an increasingly problematised area given the fact that many artists' practices are characterised by collaboration with others, or in several cases by outsourcing the fabrication of artworks to dedicated art manufacturers, whilst still retaining and asserting the status of being the singular artist. This is especially true of large-scale installation works and is perhaps an overhang from the concept of the Romantic artist as individualist genius.

It seemed much more of an honest and straightforward approach to present these works under a group identity. In this way the notion of collaboration between all of the originators remains intact. However, given that these are interactive artworks, the final situating of a concept such as 'creator' is further complicated by the role of the audience themselves, and their ownership of an artistic experience partially brought into being by their own agency.

1.10 Practical Projects Documentation and the Accompanying DVD

The written documentation included here is supplemented by digital audio, video and photographic documentation that can be accessed on the DVD that accompanies the thesis.



Relevant audio-visual documentation, accessed on the DVD, is indicated and referenced throughout the text by this icon.

Chapter 2 The Earth's 4.5 Billion Year Old Electronic Music Composition¹⁰



This chapter is accompanied by video documentation of the interactive sound installation *The Earth's 4.5 Billion Year Old Electronic Music Composition* on the accompanying DVD.

Video documentation of the work taken at the Interactive Agents exhibition *Radioworks*, SHUNT Vaults, London, May 2007.

2.1 Introduction

Radio signals created by the planet itself, surround us at all times wherever we are. At parts of the frequency range far below that of most man-made radio transmissions, these phenomena can be thought of as a level of sonic reality beyond (although surrounding) our daily sound experience. For although radio waves are generated by vibrations in electro-magnetic materials rather than air particles (as is the case with sound waves) we nonetheless tend to think of radio as a purely sonic medium.

¹⁰ This chapter is a revised and expanded version of a paper that was first published in the proceedings of the Cybersonica Symposium, Institute of Contemporary Arts (ICA), London in 2002. (McGinley, 2002).

These naturally occurring emissions, although undetectable to the naked ear, are the sonic consequences of a number of natural atmospheric phenomena, and indeed, with further research, scientists believe that they have potentially much to tell us about our planet, the structure of its atmosphere, and its circadian operations.

This chapter presents and discusses the development and construction of an interactive sound installation entitled *The Earth's 4.5 Billion Year Old Electronic Music Composition*, created by Interactive Agents in 2002 and first presented in June of that year at the inaugural Cybersonica Digital Sound and Music Festival in London.

2.2 Description of the Work

At any one moment there are several electrical storms in progress around the planet. This installation takes as its starting point, and explores, the interception of impulsive electro-magnetic signals generated by lightning. A considerable proportion of radio atmospherics is due to the direct and indirect effects of electrical storms on the upper layers of the atmosphere.

Utilising both antique valve-based short wave radio equipment, and a

multi-triggered gallery environment, the installation allows us the opportunity to hear the Earth's own natural electro-acoustic composition, which is as old as the planet itself, and is continuously unfolding around us.

The input channels of the system, which consist of a combination of real-time reception of short-wave atmospheric emissions and digital recordings of various types of *Sferics* (short for VLF (Very Low Frequency¹¹) atmospherics), and natural thunder, are fed via a set of triggers into the audio system.

In the physical realisation of this installation I was assisted by Philip Arnold who was responsible for the mechanical and structural integrity of the work and Dermot McGinley who designed and constructed the electronic control systems. Further discussion of this collaborative approach can be found in the introductory chapter of this thesis in section 1.9.

2.3 The Sferics and Whistlers Phenomena

The first major scholarly work to deal at length with Sferics interference

¹¹ The Very Low Frequency (VLF) band refers to radio frequencies within the range of 3 – 30 kHz.

(most notably the Whistler phenomena) appeared in 1965 by Robert A. Helliwell of Stanford University (Helliwell, 1993). Helliwell reports that the early investigations of these phenomena were fairly obscure, and date from 1894 when W.H. Preece of the General Post Office reported that early wireless and Morse operators experienced strange “musical” interference on long-distance radio connections. The next key advancement of this fledgling theory was made by H. Barkhausen in 1919, whose research Helliwell summarises as follows:

“During World War I amplifiers were used on both sides of the front to overhear enemy telephone conversations . . . a strange whistling sound could be heard on the telephone at certain times. Soldiers would say, “You can hear the grenades fly.” (...) Barkhausen considered that the amplifier itself, perhaps excited by an especially strong atmospheric disturbance, could produce the characteristic oscillations. However, in the laboratory he tried in vain to evoke whistling noises by using strong impulsive currents and direct spark gaps. (...). He concluded that the phenomenon was unexplainable at that time. (Helliwell, 1993: 11-12)

It was not until the 1950s that the generally accepted theory of VLF Whistlers and related phenomena were formulated. This theory suggests a complex interaction between terrestrial lightning strikes, the ionosphere, magnetosphere and the solar wind.

Sferics are the most common naturally occurring VLF radio entities which

are caused by lightning strikes, and have a non-pitched crackling sound, similar to atmospheric interference experienced on other more common radio bands. The signal reaches the receiver by being ducted between the Earth's surface and the ionosphere, with the original lightning activity taking place within a couple of hundred kilometres from the reception location.

Under certain conditions the natural radio signal is ducted further out into space, into the layers of the magnetosphere, and returns to Earth via the geomagnetic lines of force created by the Earth's magnetic field. The signal is thus distributed over a very large area, with reception being possible in the opposite polar hemisphere to the original lightning discharge. This gives rise to the characteristic Whistler emissions, as the higher radio frequencies reach the receiver before the lower ones, due to a refractive effect. This causes a separation of the frequencies, and a sliding pitch event when detected on a VLF radio receiver.

2.4 Development of the Installation

The origins of this first installation project, as stated previously in the introductory chapter of this thesis, can be traced back to the abandoned *Moonbounce* project of 1997 – 98, as this represents my initial attempts at

the integration of space radio techniques and phenomena into a compositional practice. The purely musical issues that hindered the realisation of that project (as opposed to the technical and production challenges which at the time were also insurmountable) can be seen in many ways to have informed directly the approach taken in this subsequent project. Specifically, these issues involved the disinclination to place sonic material that represented continuous streams of sonified space data within what appeared to be more or less arbitrarily fixed traditional instrumental and performance contexts. Any organisation of sonic materials that I might choose to fix into a score seemed to me, in this context, to be as good as any other. Therefore I resolved, even at that early stage, that such a project could only progress if an approach could be found whereby these space-derived elements were not being essentially relegated to the superficial level of mere sound effects within musical structures otherwise developed for instrumental or electronic performance. Rather, these sonic phenomena had to be embodied and explored on their own terms within artistic situations and contexts expressly developed for this purpose.

It was also during the phase of background research into the techniques of radio amateurs' use of the Moon as a passive communication satellite

(through a practice known as Earth-Moon-Earth (EME) or Moonbounce) that I became aware of the widespread interest among certain radio amateurs of monitoring phenomena such as Spherics and Whistlers. This was often achieved with the absolute minimum of low – tech equipment such as a home-built VLF receiver and a makeshift antenna, which was appealing precisely because of this elegance and simplicity of means.

Furthermore, during this period, I was interested in exploring (from a compositional perspective) that which Rachel Armstrong had termed *sci – fi aesthetics*, which she characterised as the tendency of:

“A number of visionary artists [who] are revealing to their audiences marvelous but credible visions of another material reality, utilising a sci-fi narrative and a scientific methodology to rationalise their ideas. This framework allows them to operate within the limits of scientific possibility but does not force them to surrender their artistic vision and imaginative exuberance to its conventions. Invading the laboratories, stealing scientific technique in order to expose our complacent dependency on scientific progress, they are challenging the truths presented by the scientific establishment”. (Armstrong, 1995: 4 – 5).

Even though the artistic appropriation of scientific research outcomes came later and is more prominent in the second and third installation projects (*The Hydro-Acoustic Big Bang Filter* and *The Heliosonic Resonator*, respectively), my early readings of this concept centred on attempts to

reference or explore notions of sci-fi that were perhaps more pop cultural in nature and the relationships (and effects) of this on what we might describe as observable ‘scientific reality’. Indeed, it was this facet that was most influential in the decision to embark on this project, once the connection had been made between the sonic qualities of primarily the Whistler emissions and the kinds of musical gestures and timbres archetypically associated with early sci-fi film production (principally those of the Theremin or initial synthesiser technologies).

The resolution to realise the piece as a sound installation came in late 2001 when I had the opportunity to create a work for the first Cybersonica festival in London. It should be borne in mind that, at the time, I considered this installation project as something of an adjunct or side project to my electro-acoustic compositional practice and nothing like the critical change of artistic direction that it proved to become. However, I had for some time felt dissatisfied, not only with the act of organising sound in set temporal relationships on tape or fixed media, but also with a number of practices associated with electro-acoustic and traditional concert modes of performance. My discontent with reference to this second point mostly involved the orientation and levels of active involvement of the audience.

At the time I felt that, by presenting a work in the form of an environment into which one could enter, both interactive and participatory in nature, represented a means of addressing both issues. Thus, the role of the composer became one of designating the sound material, parameters, conceptual framework and spatial characteristics of a piece, whilst moment-to-moment sonic organisation became a resultant factor of the activity of the InterActors.

2.5 The Original Installation Design Concept

Progressing from the idea of a spatial environment, the first iteration of the design concept for the installation was somewhat different from its final form (see fig. 2.1). The original intention was to realise the work within a gallery space of approximately 6m². A number of intersecting infra-red and ultrasonic beams were to traverse the space, triggering the composite four channel sound and light system via a series of combinatorial logic circuits. This arrangement would facilitate the production of a number of intuitive and counter-intuitive states initiated by InterActors intersecting various combinations of beams in succession. In retrospect, this concept might not have worked quite so well as the final, more simplified arrangement, as the

more advanced level of complexity implied would have been less directly responsive and thus precluded an InterActor from correlating their activities with the corresponding reaction of the system. In other words, direct attribution of trigger and response would have been minimised and obscured. However, the exact nature of this proposed system, together with its practical modes of interaction were never fully developed as this scheme was subsequently superseded by the final design of the work.

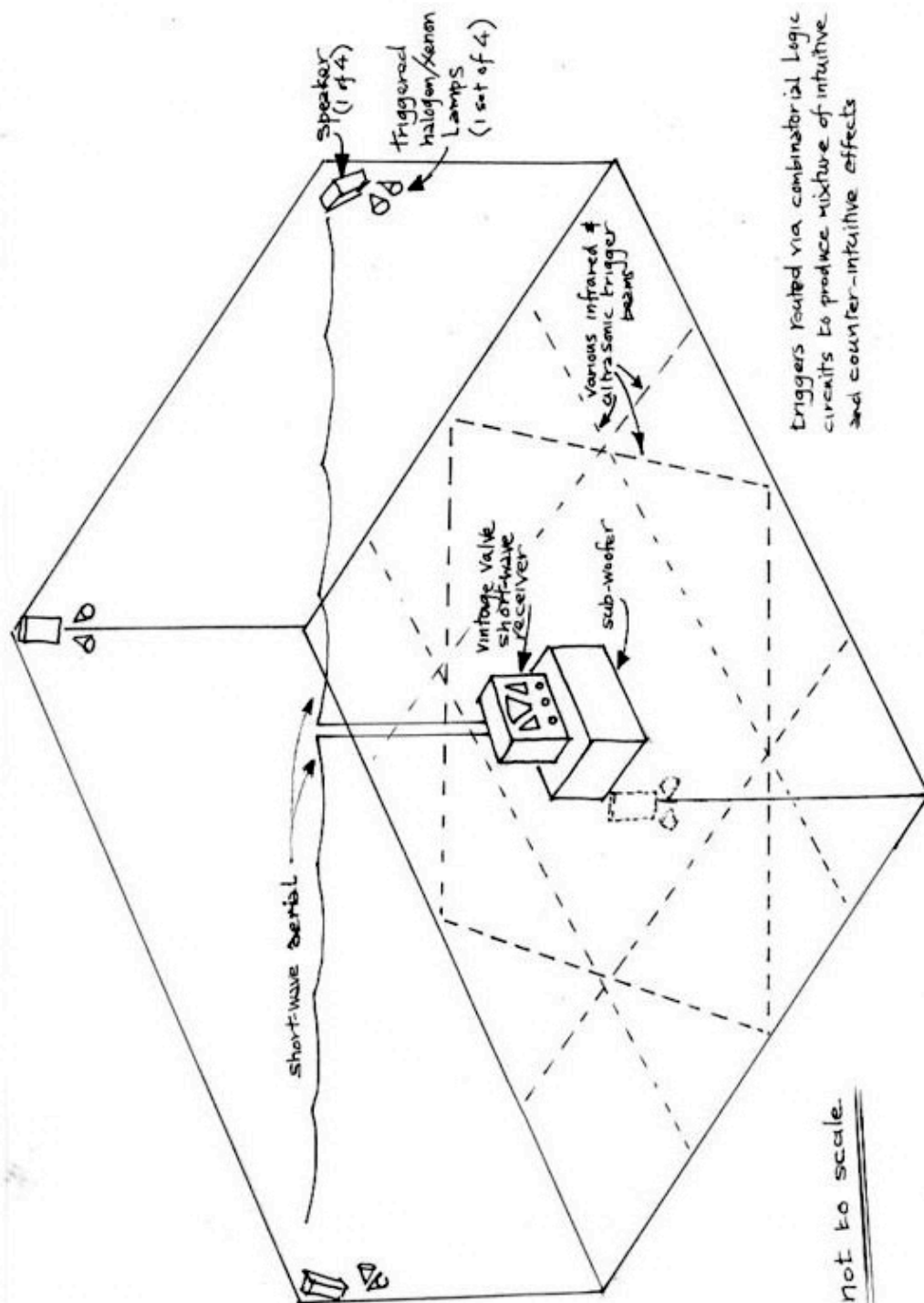


Fig. 2.1: *The Earth's 4.5 Billion Year Old Electronic Music Composition*: the first design concept for the installation. This was to be realised within a gallery space of approx. 6m^2 . The 1950s radio made its first appearance as a prominent focal point at this early stage and can be seen as residual in the final installation version of the work.

Residual from this early version of the layout was the 1950s valve radio (see fig. 2.2), which is intended to have a number of functions. Firstly, this artifact situates the idea of ‘radio’ within the piece, especially given the fact that most people’s experience of radio atmospherics is associated with their use of domestic equipment (although the increasing proliferation of modern digital tuners means that this phenomena in itself is becoming less familiar). A technological anachronism from a bygone era, with exposed valves glowing and around fifty years of accumulated dust on the components visible through the addition of a specially-fabricated Perspex back panel, seemed more evocative than any of its contemporary descendents. Secondly, the radio offered the potential of another interactive dimension to the piece. Since it is a fully working model, the InterActor can choose to experiment with the controls, scanning the stations and changing tone and volume, thereby introducing the potential of an endless variety of unique sonic occurrences into the work, derived from everyday broadcast material, other species of atmospherics and static. This appearance of the radio also marked the first instance of the appropriation of antique audio equipment within this series of works, a practice further explored in both *The Cosmic Phonograph* (2004) and *Stockholm Sound Sanctuaries* (2004 – 2005). This facet can thus

be considered as an important thematic connection and point of intersection between these works.



Fig. 2.2: Two details of the installation showing the 1951 Marconi valve radio. This was fitted with a Perspex back panel to allow the InterActors to see the valves glowing inside, together with the accumulation of about fifty years worth of dust.

The original spatial concept was finally abandoned due to the fact that the Cybersonica exhibition changed its venue from the expansive Regency interiors on the first floor of the London ICA at Carlton House Terrace in St.James' to the more compact shop front space at the now defunct Golden Square Gallery in Soho. The curators of the exhibition thus decided that only a 10m² footprint would be available, so the final design concept was considered the optimal solution in the circumstances. It retains something of the sense of scale of the original, whilst re-imagining this in terms of a monumental 10m³ steel space frame, thus more formally delineating the area for InterActor movement and engagement with the work.

This re-design, although necessitated through circumstance, can be seen as another pivotal moment in the development of the practical portfolio of installation works as the emphasis shifted away from the idea of creating an open gallery environment to that of fabricating a work with more of a large-scale structural orientation. Repercussions of this decision can thus be found, to a greater or lesser extent, in all of the subsequent works.

2.6 Final Installation Design Concept and Technical Overview

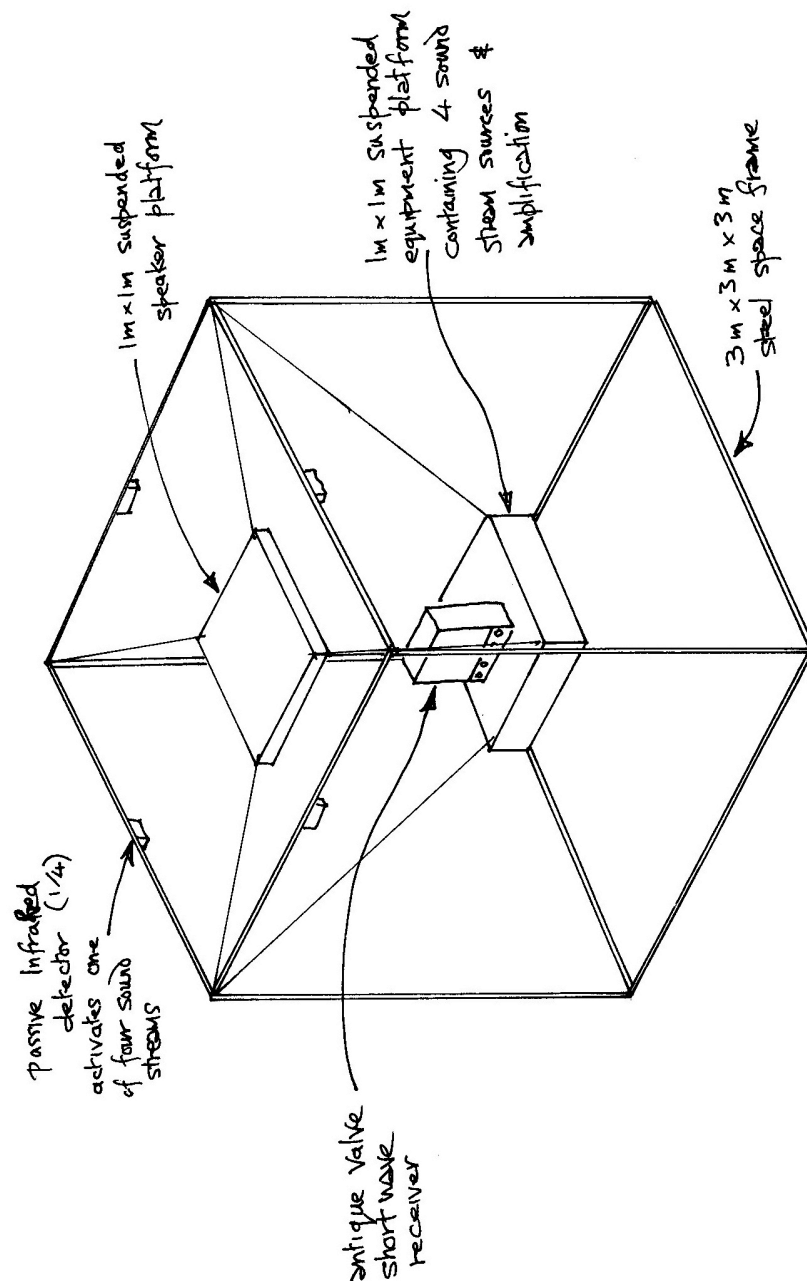


Fig. 2.3: An initial layout sketch of *The Earth's 4.5 Billion Year Old Electronic Music Composition* (2002) by Interactive Agents. The suspended planer speaker was replaced in the final version by four speakers in each of the four upper corners of the largest steel

space frame. The Passive Infra-Red (PIR) detectors were also moved and were finally placed in a similar formation on the underside of the equipment platform.

The installation as finally realised comprises a sound palette, which is presented via a multi-channel triggered gallery environment. The work consists of a 3m³ steel space frame within the centre of which is suspended another 1m³ steel space frame. The internal frame supports a plinth which is surmounted by a 1951 Marconi valve radio. The plinth houses the custom control electronics, playback, and amplification equipment for the installation. Four passive infra-red (PIR) sensors are attached to the underside of the plinth to detect the presence of InterActors on each side of the cube. Four small speakers are attached to the top corners of the upper frame, pointing internally for optimal localisation of the sound. A further sub-woofer is housed within the plinth to provide low frequency capability to the system in order to lend a degree of authenticity to the reproduction of the rolls of thunder.

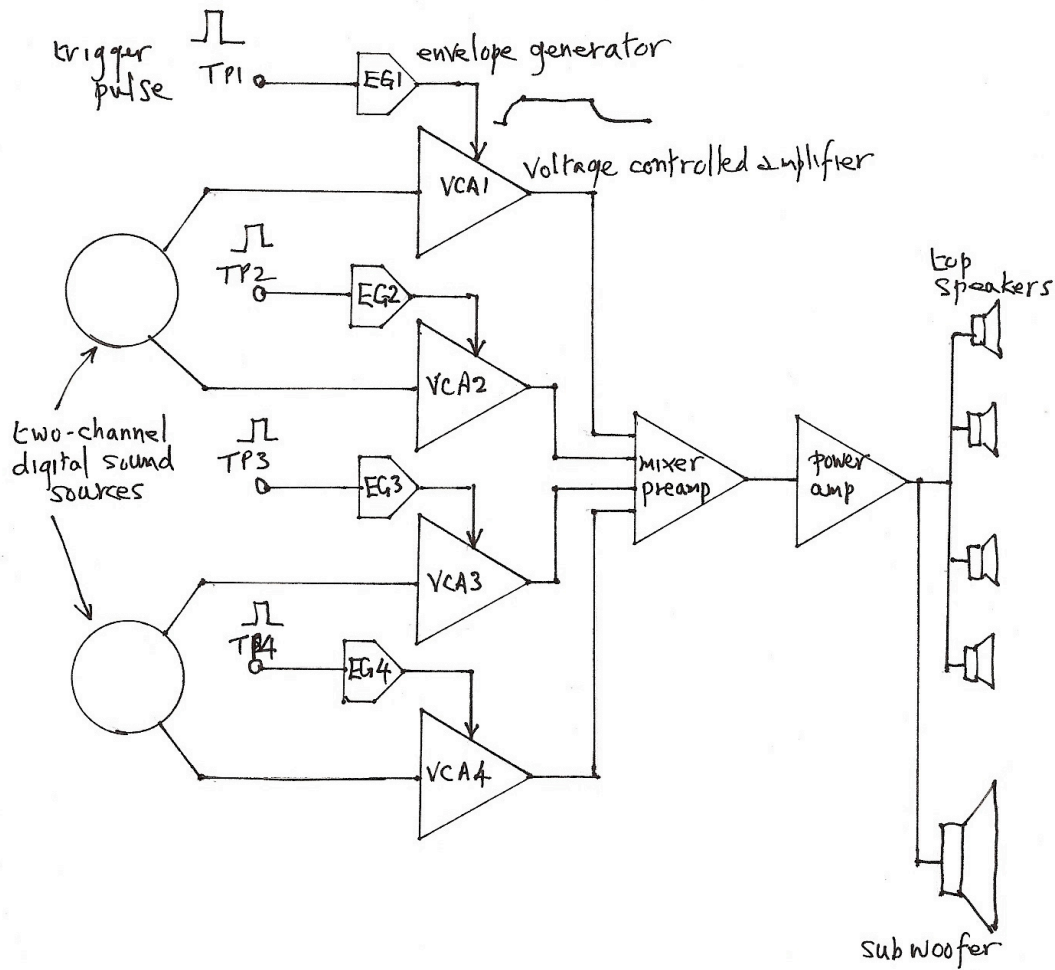


Fig 2.4: *The Earth's 4.5 Billion Year Old Electronic Music Composition (2002)*. Electronics system schematic.

The sound sources of the system are a combination of real-time short-wave atmospheric emissions received by the Marconi set and four channels of digital recordings of various types of Sferics, Whistlers and natural thunder. Some of the Sferics recordings were processed to further transform them, such that they resemble natural thunder. This was intended as a semi-

fabricated sonic construction, conceptually equidistant between the mediated and unmediated sounds related to electrical storms.

Each channel is fed into its own voltage-controlled amplifier (VCA), which is modulated via the IR sensors. The trigger voltages from the PIR sensors are used to control individual attack/sustain/decay circuits, the outputs of which are used to drive the VCAs. Thus when the presence of an InterActor is detected, the appropriate channel is faded in for a predetermined time before being faded out. The role of the live atmospherics from the Marconi set are under the direct control of the InterActors should they choose to manipulate the tuning, tone and volume controls of the receiver.

The installation thus creates a time-sampling matrix giving a large number of temporal variations and, like the natural composition itself, is unlikely ever to repeat itself.



Fig. 2.5: A studio view of *The Earth's 4.5 Billion Year Old Electronic Music Composition* (2002) by Interactive Agents.



Fig. 2.6: Installation view of *The Earth's 4.5 Billion Year Old Electronic Music Composition* at the inaugural Cybersonica Festival of Sound and Music at the now defunct Golden Square Gallery, London, W1, June 2002.

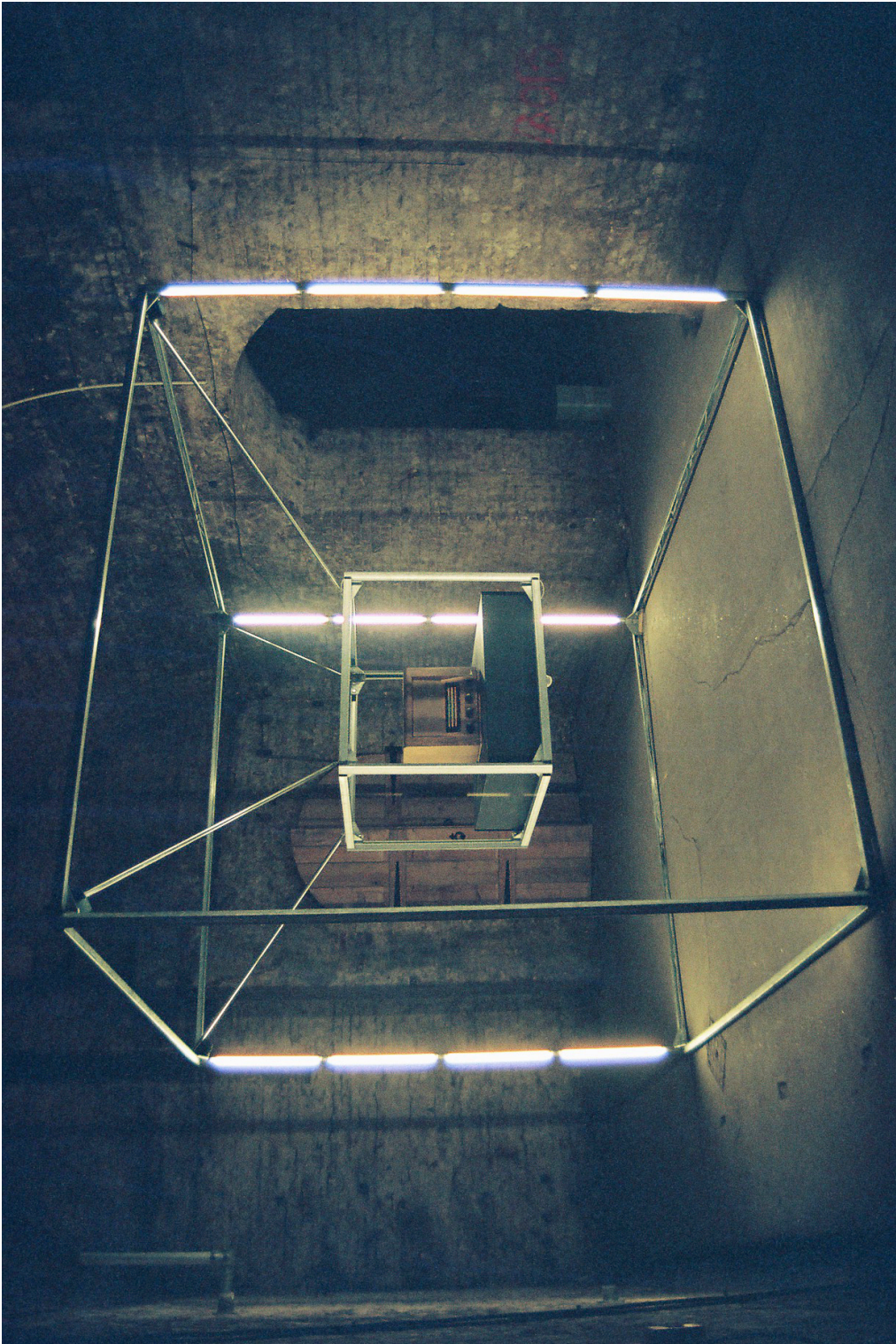


Fig. 2.6: An installation view of *The Earth's 4.5 Billion Year Old Electronic Music Composition* (2002) by Interactive Agents (Version 2) at SHUNT Vaults, May 2007. This final version has additional strip lighting within the uprights of the main cube.

Chapter 3 The Hydro-Acoustic Big Bang Filter



This chapter is accompanied by video documentation of the interactive sound installation *The Hydro-Acoustic Big Bang Filter* (2003 – 2006) on the accompanying DVD.

Video documentation of the final version of the work (2006) taken at the Interactive Agents exhibition *Radioworks*, SHUNT Vaults, London, May 2007.

3.1 Description of the Work

The installation is effectively a large musical instrument that allows members of the audience (or InterActors) the opportunity, not only to experience the sound of the Big Bang, but also to ‘play’ it. The installation consists of three hydro-stanchions, realised in two metre lengths of high-pressure cast acrylic tubing. At the top of the structure are sonic transducers, which excite the columns with the Big Bang audio signal. At the base is a pump system, which fills the stanchions with water, each stanchion being filled independently. The pump, lighting and sound for each column is controlled via an active infra-red sensor, where an infra-red beam is interrupted by any gestural movement from the InterActor. This allows the InterActor(s) quite a delicate level of control over the pitch of the resultant

sound by changing the level of water in the stanchions.

At the same time, the installation operates as a kind of synthesiser, as the changing water levels constantly modulate the sound, and with the three stanchions operating independently, a number of very interesting effects are created. The advantage of a synthesiser such as this is that the InterActors not only hear, but also quite dramatically see, the results of these modulations.

The sound used in the installation is an audio manifestation of the Cosmic Microwave Background (CMB), widely believed by cosmologists and astrophysicists to be residual radiation from the Big Bang itself, some 15 billion years ago. It was first isolated by Arno Pensias and Robert Wilson at Bell Labs in 1965, a discovery for which they were awarded the Nobel Prize in 1978 (Wilson, 1978).

The sonification used in this installation is derived from the work of Professor Mark Whittle of the University of Virginia, who has undertaken an extensive study of modelling this Big Bang sound, that he has termed Big Bang Acoustics (Whittle, 2008).

In the physical realisation of this installation I was assisted by Philip Arnold who was responsible for the mechanical and structural integrity of the work and Dermot McGinley who designed and constructed the electronic control systems. Further discussion of this collaborative approach can be found in the introductory chapter of this thesis in section 1.9.

3.2 Technical Overview of *The Hydro-Acoustic Big Bang Filter*

The following is a technical explanation of the main constituent parts of the final version of *The Hydro-Acoustic Big Bang Filter*:

3.2.1 Superstructure

The superstructure is comprised of three main elements: a 50mm steel tubular backbone, as the primary structural element, three 100mm cast acrylic tubes and four 1200mm composite discs, bonded perpendicular to the plane of the acrylic tubes. These discs provide both containment for the electronics and hydraulics and also anchor the backbone to the acrylic tubes, which are arranged in a delta formation around it. A secondary function of the backbone is to provide a conduit for power and telemetry.

3.2.2 Hydro-stanchions

These are realised in three-metre lengths of high-pressure cast acrylic tubing with a wall thickness of 3mm. These stanchions serve two main purposes: the first of which is to allow the InterActor a clear view of the dynamic fluid tuning pistons which constitute the main visual element of the piece; the second is to provide a tuneable cavity with a bandwidth extending over the range of 800Hz-7kHz. The combination of tuneable cavity and fluid boundaries provides a mechanical manifestation of a band-pass filter. The bandwidth (Q) is a function of the cavity diameter; and the resonant frequency (f_s) is the result of the length of free air at any given moment within the tube.

The use of a fluidic medium (in this case water) has facilitated the creation of a compact means of mechanical modulation. As this method is almost silent it does not negatively impact upon the sonic experience.

3.2.3 Tuned Cavity Exciters

Due to the nature of a filter, only a small amount of energy within the pass band is transmitted. Compounded with the inefficient coupling due to the mismatched mechanical impedance between transducer and filter, it is necessary to use a highly efficient exciter to energise the cavity with a relatively large signal. This translates into a comfortable listening volume within the periphery of the instrument.

3.2.4 Sensor Array

Three infra-red beam sensors, each aligned with its respective hydro-stanchion are partially recessed into the third composite disc, at approximately 2.4 metres from the base. A reflector for each sensor is recessed into the second disc, thus creating an invisible detection zone between the InterActor and anywhere along the outward facing area of each stanchion. On operation of any one of the three sensors, the installation is awoken from its quiescent state by triggering both internal lighting and sonic material. Each sensor also provides direct operation of its respective stanchions hydraulic pump, therefore allowing the InterActor accurate

control of pitch.

The sensor interface electronics have been designed to allow the InterActor the ability to not only trigger the piece but also, through practice, play it like a musical instrument.

3.2.5 Sound

The use of three non-coincident mediated sound streams, originating from the audio manifestation of the Cosmic Microwave Background radiation, allows for a very large number of sonic permutations. The broad-spectrum signal is first processed to be suitable for manipulation by mechanical band-pass filtering. This relatively basic process endows the signal with equally distributed power density for any given bandwidth and is achieved by the use of a -6dB/octave low-pass filter.

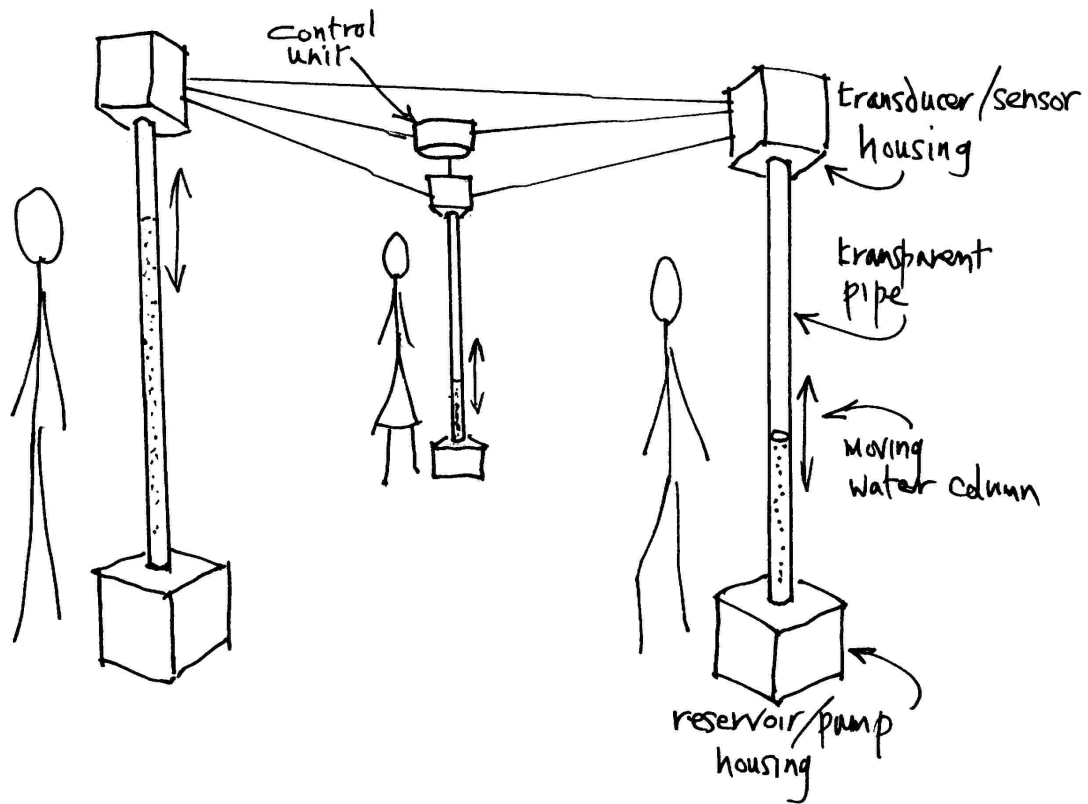


Fig. 3.1: An initial sketch of the installation structure for *The Hydro-Acoustic Big Bang Filter* (version 1) (2003).



Fig. 3.3: A studio view of a prototype of *The Hydro-Acoustic Big Bang Filter* (version I) (2003).



Fig. 3.4: *The Hydro-Acoustic Big Bang Filter (Version II)*, Installation view at SHUNT Vaults, May 2007. Demonstrating the operation of the interface.

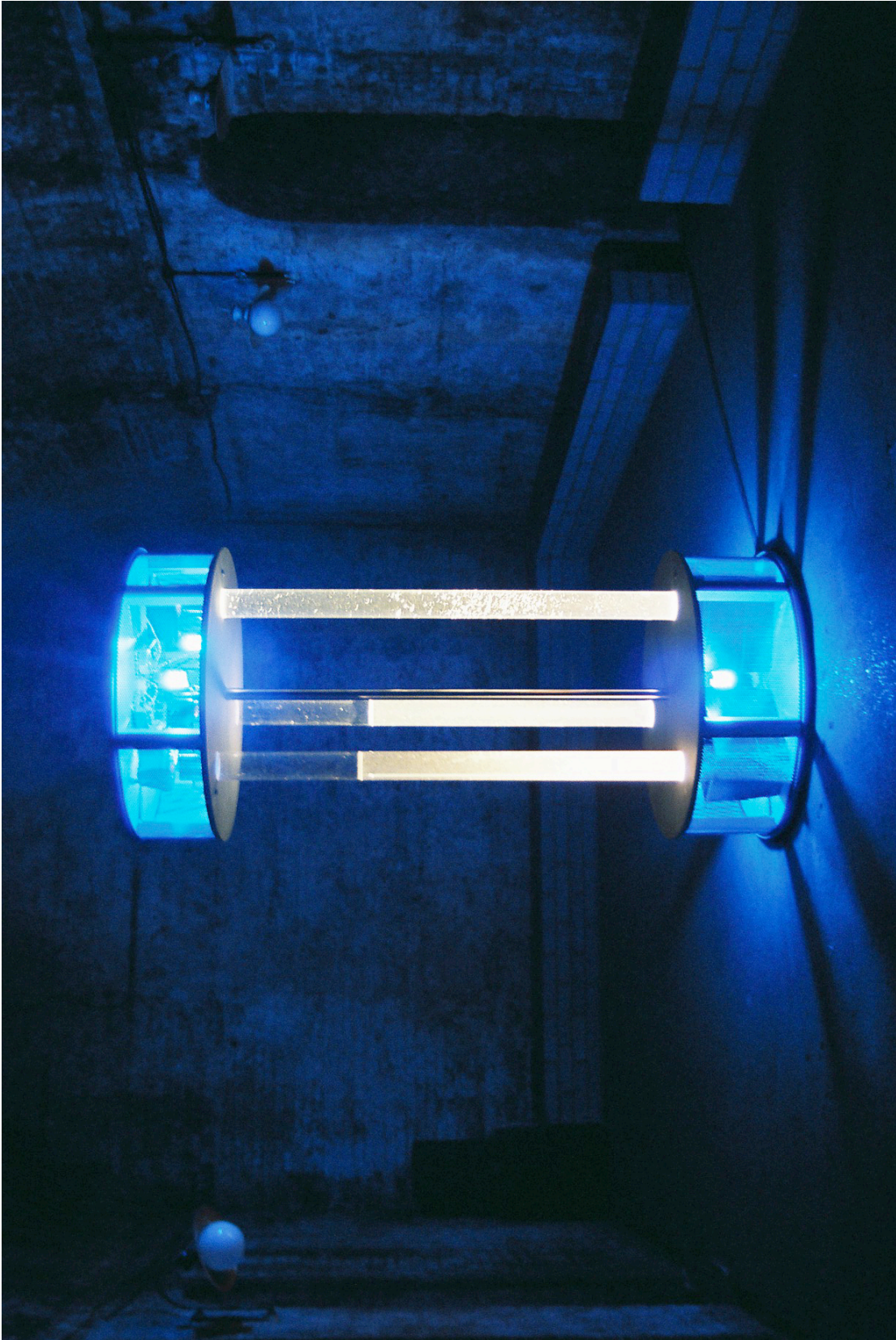


Fig.3.5: *The Hydro-Acoustic Big Bang Filter* (Version II), Installation view at SHUNT Vaults, May 2007.

3.3 From the Celestial Monochord to *The Cosmic Phonograph*

It would appear, at first glance, that music and cosmology have been inextricably linked since at least the 5th century BC. Ever since Pythagoras (after his enlightening experiences with the “harmonious blacksmith”) supposedly demonstrated the principles of celestial mechanics through the harmonics of a monochord, there has existed a kind of perceivable dialogue between the pursuit of music and the pursuit of our understanding of the cosmos.

This connection, however dubious, has resonated down the centuries, and this section examines certain aspects of music, noise and cosmology as a means to offer some theoretical context for the development of the sound installations *The Hydro-Acoustic Big Bang Filter* (2003 – 2006) and the preparatory work *The Cosmic Phonograph* (2004) (see Chapter 4). These works take as one of their points of departure an audio manifestation of the after-echoes of the Big Bang, some 15 billion years ago.

However, the validity of beginning the story of musical cosmology with Pythagoras is in itself highly questionable, and it is not therefore surprising

that Trevor Wishart once remarked that “ ...the concept of the *Harmony of the Spheres*, [is] one of the most persistent and misleading conceptions ever to animate the human mind.” (Wishart, 1985: 46).

One can perhaps trace an allegorical significance for the classical notion of the music of the spheres in terms of modern observational cosmology with particular reference to the CMB. This will become especially apparent in the later sections of this chapter with examples of senior space scientists and cosmologists utilising sound synthesis techniques to create sonic models of CMB data.

Perhaps pertinent to the linking of especially electronic music to cosmology is the fact that radio astronomy became the main means of observation within current cosmology, whilst simultaneously at other areas of the electro-magnetic spectrum radio waves became one of the main carriers of music, news and telecommunications in general throughout the last century.

3.4 Noise: Intimations of Entropy

Traditionally thought of as a pejorative term in common usage, noise is also

often assigned a similarly negative meaning when applied to music and recording technologies. This is also the case if we consider the position of noise conceptions in relation to fields of enquiry such as information theory, telecommunications and radio astronomy.

Always a subjective term with ‘one person’s music being another’s noise’, it was perhaps with the rise of urbanisation that daily noise in the local sphere became perceived as a problem. It was also later with the discovery and utilisation of electro-magnetism that we became aware of noise from beyond our local sphere, either in terms of interference signals from our immediate atmosphere or from elsewhere in the cosmos.

As a means of discussing some of the ideas related to framing the use of cosmic and galactic noise in the sound installations mentioned previously, the current discussion takes as one of its agendas a positive approach to the concept of noise and systems interference, not just as a sound source in itself but as one of the major elements for the communication of meaning in a work of art.

This approach stems from viewing noise phenomena not as the ultimate

absence of information, or as conclusive evidence of the entropic system within which we all find ourselves, but as a kind of sonic blank canvas, ready to assimilate any number of possible artistic conceptions and propositions. Likewise, noise can also be viewed as a constantly shifting final frontier for certain lines of scientific enquiry, the once apparently random, all pervasive interference from which new models of our universe (and thus our place within it) have constantly been extracted. Furthermore, our current usage of noise as an artistic proposition, in our post-industrial ‘techno-verse’, passes easily from that which we physically hear, to that which is rendered naturally inaudible without sonification through the use of technology.

3.5 Beneath the Cosmic Noise Floor

The main naturally inaudible noise source that is of concern here is the Cosmic Microwave Background (CMB) considered by cosmologists to be residual radiation from the Big Bang. The subsequent expansion of the fabric of the universe following the Big Bang means that the radiation seems to permeate all points of the known universe.

Although the existence of the Cosmic Microwave Background was predicted earlier in the 20th century, it was not isolated and identified until 1965 by Arno Penzias and Robert W. Wilson at Bell Labs utilising a system involving a 20 foot horn-reflector antennae and cryogenic amplification techniques which consisted of a radiometer cooled by liquid helium to temperatures below five degrees Kelvin so as not to receive noise from the earth, sky or other terrestrial sources such as electrical circuitry. This discovery, for which they were awarded the Nobel Prize for Physics in 1978, has had far reaching ramifications for contemporary cosmology in terms of what researchers know about the nature of the early universe. It was achieved by accident when the pair discovered an unexplained noise source in the system at around 4.2 Kelvin. Having investigated a number of possible sources of this noise, they were forced to consider the possibility that it was due to the fact that:

“ A pair of pigeons was roosting up in the small part of the horn where it enters the warm cab. They had covered the inside with a white material familiar to all city dwellers. We evicted the pigeons, and cleaned up their mess, but obtained only a small drop in antennae temperature.” (Wilson, 1978: 475)

Through further investigation and consultation with many leading experts the noise source was eventually correctly identified. This is another example

of meaning being projected onto seemingly random noise, a situation mirroring the earlier discoveries of radio at the turn of the century when researchers such as Marconi and Tesla heard strange and unidentified noises in their circuits, or later, in the 1930s, when Karl G. Jansky, made some of the first major discoveries that led to the establishment of modern radio astronomy while studying the nature of interference occurring on the recently inaugurated trans-Atlantic radio telephone service (Sullivan, 1982).

All these instances of “noise-mapping” could be attributed to what Erik Davis in his book *TechGnosis* has referred to as:

“...the human imagination and its boundless ability to project meaningful patterns into the random static of the universe. But this argument, however true in its own terms, distorts the larger technocultural loop: New technologies of perception and communication open up new spaces, and these spaces are always mapped, on one level or another, through the imagination.” (Davis, 1998: 74)

3.6 Channelling the CMB

“The sky above the port was the colour of television, tuned to a dead channel” (Gibson, 1984:9)

In a personal e-mail communication to this author, Jan Tauber, Project Scientist working on the European Space Agency’s (ESA) Planck space

probe (then due for launch in 2007) at the Astrophysics Division of the European Space Agency in the Netherlands, described the CMB signal thus:

“the CMB signal as a function of time consists of gaussian-distributed (or flat-spectrum) noise. Translated to the audio range, it would sound as a rumble or hiss depending on the bandwidth you select. Its spatial distribution on the sky is of course not gaussian but has a rather complicated statistical spectrum with one main peak at ~ 1 degree angular scale and several other peaks at smaller angular scales.”
(Tauber, 2004)

He goes on to state that “if you tune your TV or radio to a non-existing station you get a very good audio representation of the CMB signal in time.” (Tauber, 2004). There have been a number of attempts in recent years by astrophysicists and others to create audio representations of the CMB signal, to aid in both communication and analysis of the statistical data, and in many ways these acoustic modelling processes can be viewed as useful companions to the more widespread visual representations of the CMB signal, that have appeared in recent years especially since the first images from NASA’s WMAP (Wilkinson Microwave Anisotropy Probe) were released in 2003 (see figure 3.6).

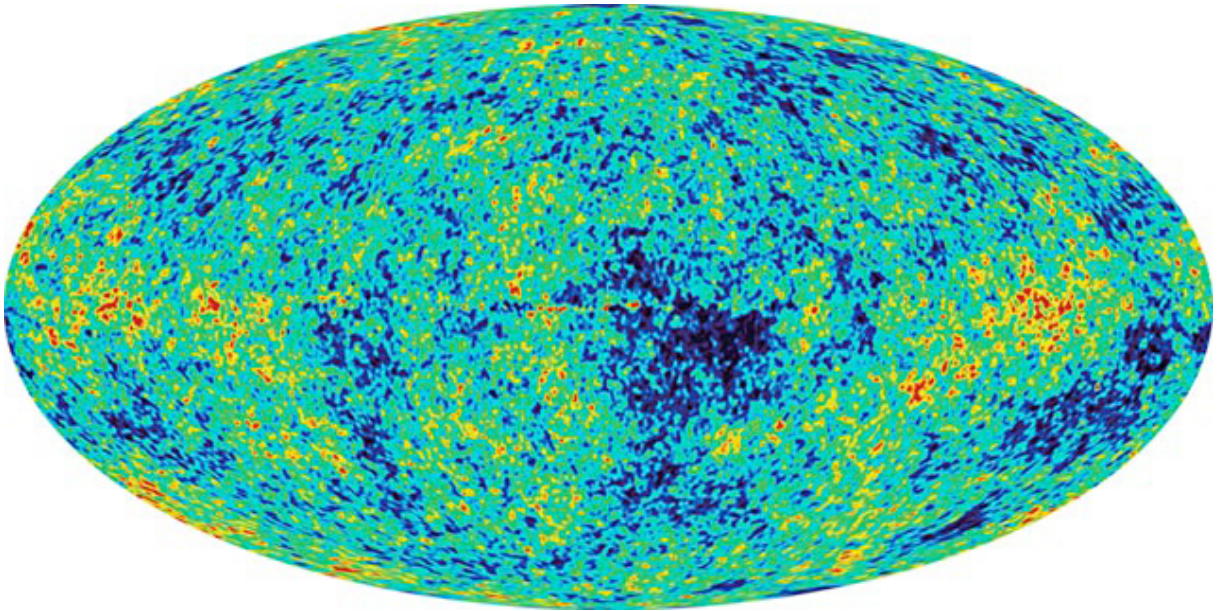


Fig. 3.6: “The Microwave Sky: the first detailed, all-sky picture of the infant universe. The WMAP image reveals 13 billion+ year old temperature fluctuations (shown as colour differences) that correspond to the seeds that grew to become the galaxies. Encoded in the patterns are the answers to many age-old questions, such as the age and geometry of the Universe.” (NASA/WMAP Science Team, 2004)¹²

One of the recent major attempts at creating a sonification of this data was completed by Professor Mark Whittle at the Department of Astronomy, University of Virginia. I quote once again from a personal email:

“the CMB that we directly observe yields a sound which is constant in form and volume (it is a hissing roar). For various technical reasons, the sound we “see” from the CMB is distorted in several ways. I have been able to run some complex computer simulations of the early universe (NOT written by me, but by experts in this field) and these yield “purer” versions of the sound (more like what is actually present at that time in the Universe, rather than what we see now). That cleaned

¹² Online Image Source and commentary from the NASA/WMAP Science Team at http://map.gsfc.nasa.gov/m_or.html

sound is not much different, but it is somewhat. Finally I've also used these simulations to generate the time evolution of the sound, starting about 100 years after the big bang and ending around 380,000 years (which is when we see the CMB). It is a descending scream, starting at high frequencies and ending in the final hissing roar that you get for the single ("visible") CMB sound. I also am intending to run some models which take the sound on further after recombination, when the sound waves get much stronger and have higher frequencies as the gas falls into the gravitational wells formed by the Dark Matter.” (Whittle, 2004)

Many of these examples of the sonic data simulations Whittle refers to can be heard with detailed commentary and explanations of what he terms “Big Bang Acoustics” at his website¹³: this was the source of the sound material utilised in the final version of *The Hydro-Acoustic Big Bang Filter*. The use of this source material was originally suggested to me by Dr. Carolin Crawford of the Institute of Astronomy, University of Cambridge, who had previously used sound examples created by Professor Whittle to illustrate a lecture discussing the residual sounds of radio astronomy at The Royal Society, London in 2004¹⁴

Other examples of the sonification of CMB data exist, including the widely publicised attempt created by Professor John G. Cramer of the

¹³Professor Mark Whittle – Big Bang Acoustics website:
http://www.astro.virginia.edu/~dmw8f/sounds/aas/sounds_web_long_files/frame.htm

¹⁴ Professor Andy Fabian and Dr. Carolin Crawford: Heavenly Music: The Sounds of the Universe. Lecture at The Royal Society, 16th February 2004.

Department of Physics, University of Washington. This simulation is a representation of the CMB signal over time: a 100 second sound file that represents the first 760 thousand years of the universe's existence (Cramer, 2003).

An especially interesting point that comes across quite strongly in the last two pages of this overview, is the way these senior space scientists have begun discussing and experimenting with solutions in sound synthesis as statistical data models, in much the same way as a composer and sound artist may be drawn into the discussion of Big Bang cosmology as a means of creating an artistic response, and thus new ways of presenting and exploring the same data.

This points to a situation of intersection and symbiosis between the arts and the sciences, not just from a perspective that we use some of the same tools or technological solutions (e.g. computers, digital audio reproduction technology), but that we use the same data for similar purposes. The artistic response may indeed be seen as a useful extension of data processing, as it is in some ways unbounded by the need for clarity and (apparent) objectivity associated with traditional techniques of scientific representation.

Being governed more by responses founded in the imagination, principally of the artist, but hopefully transmitted through the chosen presentational strategies to the imagination of the audience, scientific data may be approached not as an absolute, but as something that is provisional, speculative and potential in terms of its effectiveness as the basis for artistic practice and reception.

This investigation into CMB cosmology in the name of art is intended as an example of a growing tendency at the beginning of the 21st century towards collaboration and cross-pollination of artistic and scientific projects. Furthermore, these developments should not be viewed as something new, but rather in the context of the Pythagorean speculations at the opening of this discussion: that we are in some sense regaining and extending the Classical ideal of unity between intellectual disciplines (after centuries of progressive over-specialisation) and that, once again, artists and scientists can feel as though they are living in the same universe.

Chapter 4 The Cosmic Phonograph (or His Master's Cosmic Background Radiation)



This chapter is accompanied by video documentation of the sound installation *The Cosmic Phonograph (or His Master's Cosmic Background Radiation)* (2004) on the accompanying DVD.

This footage was taken during the exhibition of this work at Mellanrummet Gallery, The Royal Swedish University College of Fine Arts (Kungliga Konsthögskolan), November 2004.

The installation utilises the unique mix of an antique gramophone and digital media technologies to present an audio manifestation of the Cosmic Microwave Background (CMB). This work is a companion piece and something of a preparatory study, to the final version of *The Hydro-Acoustic Big Bang Filter*, as both installations use the same source material. It was created for the Mellanrummet Gallery at The Royal Swedish University College of Fine Arts (Kungliga Konsthögskolan), and was exhibited there in November 2004.

The work has a number of constituent parts, including:

- An original molded resin model of “Nipper”, the HMV dog.
- An antique His Master’s Voice gramophone, specially prepared for digital playback of the CMB audio stream.
- The CMB audio stream. This is presented through a series of intersecting audio loops played back on a number of CD players. On the CDs short bursts of the CMB signal is interspersed with large durations of silence. This arrangement ensures maximum organic development of the temporal placement of the CMB fragments. In short: it will never repeat itself.
- A specially-devised three channel theatrical lighting installation, controlled by a DMX system with dimmers to create a series of out-of-phase slow dimming cycles.
- The subtitles: An extremely long loop created from different texts referring either to the history of Nipper, The Gramophone Company, the discovery and continued exploration of the CMB phenomenon, as well as other texts relating to general theoretical cosmology (at times

these are presented simultaneously).

- A radio tuned to static between the channels.
- The architectural acoustics of the exhibition space.

Taken together, these elements embody the main aims of the piece. Loops are nested within loops, each of different lengths, ensuring the various elements are locked into an infinite number of temporal variations.

When dealing with the idea of the Big Bang (or even a distant echo of the event sonified billions of years later), one is immediately faced with two conceptual impossibilities:

- The human mind is unable to contemplate the sheer magnitude of forces implicated in an event such as the Big Bang.
- The human mind is unable to contemplate a time span in the order of thousands of millions of years (the currently estimated life of the universe).

The only way we can begin to imagine such things is by relating them in some way to ourselves, our own experiences and time frames. Therefore, the piece investigates a number of historical time frames, in the hope that by so doing, an audience may begin to imagine the unimaginable (or at least appreciate it). We cannot imagine the lifespan of the universe, but we can grasp the history of modern sound recording, a history of domesticated appliances such as the gramophone, radio and later television, through which, paradoxically, we can experience a remnant of the CMB signal. As Jan Tauber explained in the previous chapter. In fact an infinitesimal percentage of the noise signal of a detuned household radio or television can be traced directly back to the CMB, that is to say the Big Bang, the rest being due to such things as terrestrial thermal radiation, atmospheric interference and the national grid. Perhaps the gulf between the infinite and the commonplace is not so great after all . . .



Fig. 4.1 *The Cosmic Phonograph (or His Master's Cosmic Background Radiation)* Installation view, The Royal University College of Fine Arts Stockholm, Sweden
November 2004.

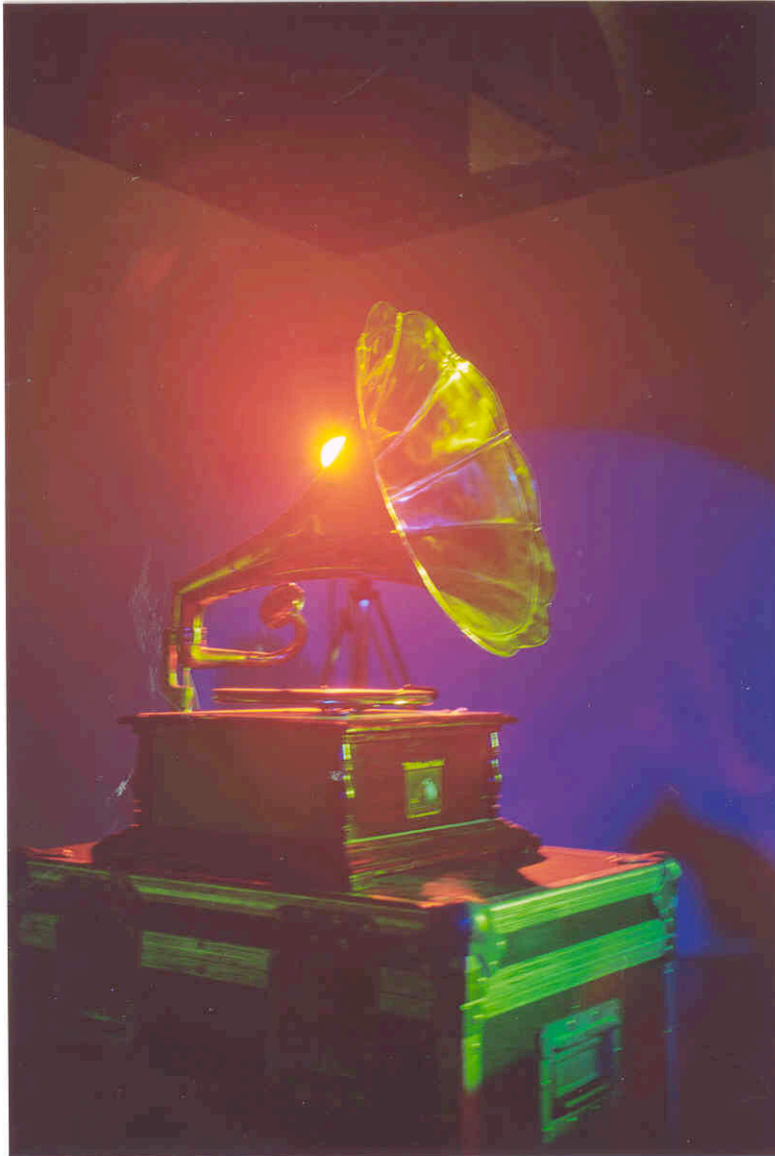


Fig. 4.2: *The Cosmic Phonograph (or His Master's Cosmic Background Radiation)*
Installation detail, The Royal University College of Fine Arts Stockholm, Sweden,
November 2004.

Chapter 5 Stockholm Sound Sanctuaries: A Public Sound Art Project

Further documentation for this project can be found on the project website at www.interactive-agents.com/soundscape.html

5.1 Introduction

This chapter presents a number of results and discusses the aims and possible contexts for a public sound art project that was carried out during 2005, exploring and documenting the soundscape of Stockholm.

The project (based on an idea by Barry Truax, Simon Fraser University, Vancouver, Canada) was entitled *Stockholm Sound Sanctuaries* and involved a public survey to identify a series of locations in Stockholm that maintain a strong acoustic character, whilst promoting quiet and reflection in an otherwise noisy city sound environment. These sites were then publicly designated as Sound Sanctuaries and each site was extensively documented using a range of media, principally digital sound recording, digital photography, and video, with this material being used as the basis for two main modes of presentation: a project website and a gallery-based interactive sound installation. Each manifestation was intended to represent

different facets of what this chapter refers to as a sonic simulacra of the city created in collaboration with its inhabitants.

5.2 Project Overview

“The most powerful action against noise may be the preservation of silence.” (Truax, 1984:97)

The above quote by the Canadian composer Barry Truax was the initial motivation for the project. In the same text, he also mentions the concept of the *Acoustic Sanctuary*, which he defined as a place, or site that retains a strong acoustic character despite other, possibly louder environments, that surround it. A Sound Sanctuary can be described as a sound oasis, a place that promotes quiet and reflection in an otherwise noisy soundscape, and if one looks for them, one can find them in several locations. A city park, a disused industrial site, a quiet alleyway, a natural wilderness in a metropolitan area or a foot tunnel or bridge.

This chapter discusses several aspects of the development of the project in Stockholm and presents a range of results under three headings, Identification, Designation and Manifestation, each of which relates to the

project's main phases. In general terms, the overall aims of the project can be expressed as follows:

- To identify a number of sites in Stockholm that may be described as Sound Sanctuaries.
- To in some way acknowledge or publicly designate these as Sound Sanctuaries, thus raising awareness in a very public way of the need for the preservation of quieter environments in our otherwise noisy world.
- To further extend this idea by documenting and presenting the outcomes of the project through the use of digital media applications, both within a gallery space as an interactive sound installation and online.

I began to formulate ideas for the project in early 2001 after having completed the first version of an education project encouraging secondary school students to research and document their local soundscape (McGinley, 2001). However, the work of realising this current version did not commence until 2004 when I started on the one-year Project Programme for

Professional Artists in Digital Media at the Swedish Royal University College of Fine Arts (Kungliga Konsthögskolan). The conception for the project in its present form was thus designed to radically function across a number of disciplines primarily from the sonic and visual arts, but also tangentially relating to the study of human experiences of, and responses to contemporary urban living.

The overriding aim, however, was that the project should manifest itself as a community arts initiative, offering in its early stages a mode of interaction and participation to all within the city who serendipitously came into contact with it and took the decision to contribute. In this way I proposed that the emergent portrait of the Stockholm soundscape would be definitively coloured, created and informed by the inhabitants of the city and their daily experiences.

5.3 Phase One: Identification

“Soon silence will have passed into legend. Man has turned his back on silence. Every day he invents machines and gadgets that multiply noise and distract man from essential life, from reflection, from spiritual immersion . . . In the midst of all the horn-blowing, howling, screeching, thundering, crashing, whistling, gnashing and chirping he feels confident.” (Jean Arp, 1948: 37).

One of the first issues to present itself in the primary phase was how to

identify the potential sites. Any group of people who know Stockholm well could list a number of possible places, but would their choices reverberate positively with the rest of the community? One person's Sound Sanctuary may be another person's Sound Purgatory! There were no guarantees that my choices (or anyone else's) would resonate sympathetically with the rest of the populace. I therefore decided that the best way to identify possible sites would be to organise some kind of public survey. This initially took the form of an online survey in which a simple questionnaire was posted to solicit nominations¹⁵. Participants were asked to complete the following particulars:

Name:

Contact Details (e-mail or other):

Propose a place or site in Stockholm that you would like to nominate as a Sound Sanctuary:

¹⁵ The nomination form for the web survey can be found at www.interactive-agents.com/soundscape.html

Location Details (address or how to reach the site):

Briefly explain your choice:

It soon became clear, however, that a survey that existed exclusively online was only part of the solution. It would not only bias the results towards that section of the population that have regular access to the web, but it would also preclude the possibility of participants stumbling across the survey in their everyday ‘real’ life (as opposed to their ‘virtual’ life). A physical manifestation of the survey at a number of sites across the city was thus necessary.

5.4 RadioActivist: An Interactive Installation/Survey

The physical manifestation of the *Sound Sanctuaries* project web survey had to fulfil certain criteria. The resultant piece had to be easily transported to a variety of locations, and had to intrigue people enough for them to investigate (and hopefully) ruminate on this slightly esoteric idea.

The survey thus took the form of an interactive installation of which there were two examples constructed: *RadioActivist I and II* (2005).

Continuing one of the major themes of this study, involving the appropriation of obsolete audio technologies (see introductory chapter, section 1.8), each work consisted of a superannuated valve radio re-fashioned as a post box. A suggestion box for sanctuaries.

5.4.1 RadioActivist I



Fig. 5.1: *RadioActivist I* (2005) Modified 1958 Grundig valve radiogram 7000/S. Installation view – Stockholm Public Library Rotunda, January 2005.

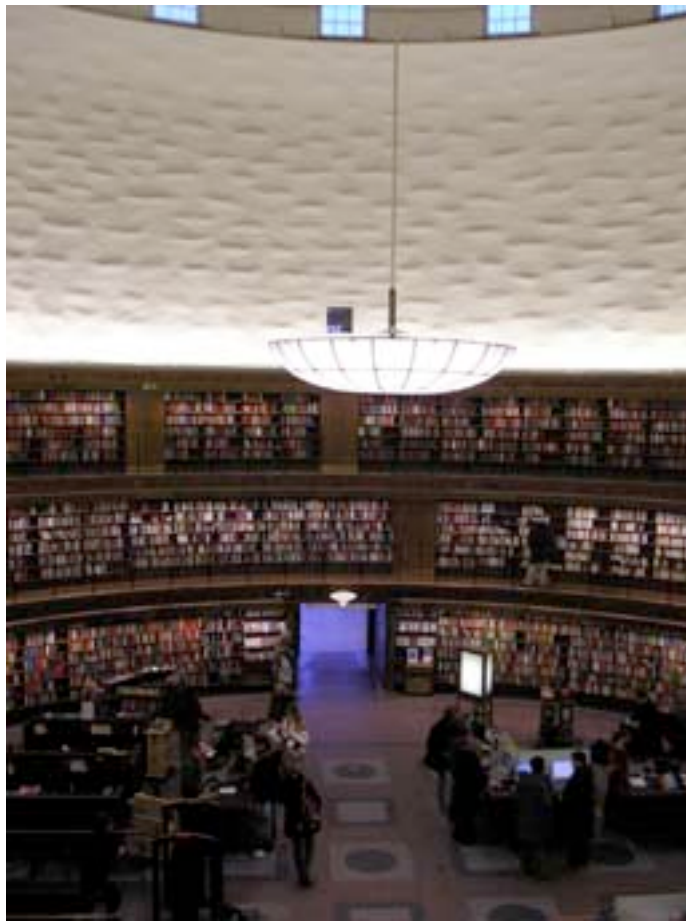


Fig. 5.2 *RadioActivist I* (2005) Modified 1958 Grundig valve radiogram 7000/S.
Installation view – Stockholm Public Library Rotunda, January 2005.



Fig. 5.3: *RadioActivist I* (2005) Modified 1958 Grundig valve radiogram 7000/S.
Installation view – Stockholm Public Library Rotunda, January 2005.



Fig.5.4: *RadioActivist I* (2005) Modified 1958 Grundig valve radiogram 7000/S.
Installation view – Stockholm Cultural Centre (Kulturhuset), January 2005.



Fig. 5.5: *RadioActivist I* (2005) Modified 1958 Grundig valve radiogram 7000/S.
Installation view – Stockholm Cultural Centre (Kulturhuset), January 2005.

5.4.2 RadioActivist II



Fig. 5.6: *RadioActivist II* (2005)
Modified 1937 AGA-Baltic valve radio LYX745.



Fig. 5.7: *RadioActivist II* (2005) Modified 1937 AGA-Baltic valve radio LYX745.
Installation view – Liljevalchs Konsthall, Stockholm, February 2005.



Fig. 12.8: *RadioActivist II* (2005) Modified 1937 AGA-Baltic valve radio LYX745.
Installation view – Liljevalchs Konsthall, Stockholm. February 2005

5.4.3 Interaction that you don't have to plug into the wall

This installation is unique in relation to the other pieces in the practical portfolio as it was based upon a species of interaction that does not require mains electricity. However, it nonetheless has a sonic element, the site of which was inside the InterActor's mind or memory. The aim of the work was to stimulate memories of sounds and locations in the city as the basis on which an InterActor was to make their nominations. The InterActor was met with the two following texts:



Fig 5.9: *RadioActivist* Instructions Panel 1¹⁶ Fig 5.10: *RadioActivist* Instructions Panel 2¹⁷


Once the InterActor has decided to participate in the work they filled out a simple questionnaire, which was then posted into the slot cut into the top of the valve radio. The questionnaire is shown here:

¹⁶ Translation of the text: “You are invited to take part in a survey to find a number of places in Stockholm that could be described as ‘Sound Sanctuaries’”. The web version of this text can also be found online at: www.interactive-agents.com/soundscape.html.

¹⁷ Translation of the text: “A Sound Sanctuary is a place or site with a strong acoustic character despite other, possibly louder environments that surround it. A Sound Sanctuary could be described as a sound oasis, a place that promotes quiet and reflection, in an otherwise noisy soundscape. Examples could include: a city park, a disused industrial site, a quiet alleyway, a natural wilderness in a metropolitan area or a foot tunnel or bridge.

Directions: 1. Answer the questions on the form
2. Post the form into the radio”

The web version of this text can also be found as part of the online survey at: www.interactive-agents.com/soundscape.html



**Stockholm
Sound Sanctuaries**

**The People
Are Listening**

Din nominering

Namn _____

Kontakt (E-post eller telefon) _____

En plats i Stockholm som du vill nominera som "Sound Sanctuary"

Kort förklaring till ditt val: _____

Fig. 5.11: *RadioActivist* questionnaire¹⁸


In this way the work facilitated a subtle re-alignment of certain interactive procedures. The InterActor was encouraged not only to imagine or remember potential sonic content, but also in nominating a location they

¹⁸ Translation of the text: "Name, Contact details (e-mail or phone), Name a place in Stockholm that you would like to nominate as a 'Sound Sanctuary', Briefly explain your choice. An interactive cgi web version of this form can be accessed at www.interactive-agents.com/soundscape.html

issued an assignment to the artist whose role it was to subsequently visit the location and document it through audio/visual media. Thus, the audience had a critical and decisive effect not only on the outcomes of the research project but also on the content of any artworks that may be derived from it.

On the following pages are included a few examples of completed questionnaires:

**Stockholm
Sound Sanctuaries**



**The People
Are Listening.**

Din nominering


Namn Sara

Kontakt (E-post eller telefon) _____

En plats i Stockholm som du vill nominera som "Sound Sanctuary" ^(och helk)
Stora Skuggan i Lil Jans Skogen

Kort förklaring till ditt val: en fantastisk plats
av ro och ända i staden - efter en promenad
genom denna bevarade skogsoas.

**Stockholm
Sound Sanctuaries**


**The People
Are Listening**

Din nominering

Namn Svaute

Kontakt (E-post eller telefon) _____

En plats i Stockholm som du vill nominera som "Sound Sanctuary" (vid affären "Myntel")
Rundeln, kupolen längs "Blå"

Kort förklaring till ditt val: Det är väldigt skuggigt/bodarna
är kul att sjunga akapella / mellan Slussen & Gästgäststugan
eller tröla där!

Fig. 5.14: An example of a completed *RadioActivist* questionnaire. Completed at Stockholm Public Library, January 2005²¹.

5.4.4 Soundmarks vs. Sanctuaries

In *The Tuning of the World* R. Murray Schafer makes the following remarks regarding the preservation of what he terms soundmarks:

“One practical task of the acoustic designer would be to draw attention

²¹ Translation of the text: “The Dome inside The Blue Passage between Slussen and The Old Town (outside the shop ‘Myntel’). It is very shadowy and fun to sing a cappella or play violin there.”

to soundmarks of distinction and, if there is good reason to do so, to fight for their preservation. The unique soundmark deserves to make history as surely as a Beethoven symphony. Its memory cannot be erased by months or years. Some soundmarks are monolithic, inscribing their signatures over the whole community. Such are the famous church or clock bells, horns or whistles. What would Salzburg be without its Salvadore Mundi, Stockholm without its Stadshuset carillon, London without Big Ben?" (Schafer, 1977:239)

In the early stages of this project I thought that it might be more straightforward to ask participants for more of this kind of monolithic, easily recognisable soundmark, as these were perhaps easier to identify than the more anonymous and obscure places that might be considered for sound sanctuary nomination. In practice, however, it seems to have worked better that the definition of what constitutes a potential site was left a little vague, because it has encouraged a number of personal responses to the sound of certain locations. This therefore influenced to some degree the outcomes of the first phase of the project, so that rather than being a list of quiet places, on some level it took on the unexpected dimension of a kind of psycho-geographical mapping of the city, with nominations resonating not just with sound memories, but also demonstrating other kinds of emotional attachment and significance.

5.5 Phase Two: Designation



Fig. 5.15: Nos. 23 and 25 Brook Street, London, UK. Visible on each building are the commemorative blue plaques.

Above are photographs of 23 and 25 Brook Street London (fig. 5.15). The German composer George Frideric Handel (1685-1759) moved into number 25 in 1725 and lived there until his death. Around two hundred years later, Jimi Hendrix (1942-1970) moved next door into number 23, and lived there in the late 1960s. A small round blue plaque can be seen on both houses, placed there by an organisation called English Heritage to commemorate these notable residents. There are hundreds of other examples across London and the UK.

It was from these British blue plaques that I took the inspiration for the idea of placing a plaque at each of the sound sanctuary sites. It represented a simple means of identification, combined with a memorable visual concept

that incorporated one of the symbols for the city of Stockholm, an image of the face of St. Erik complete with a pair of headphones, the lead of which makes out well-known landmarks of the skyline. (see fig.5.16).



Fig. 5.16: Preliminary Stockholm Sound Sanctuaries Plaque Design

Negotiations commenced shortly afterwards with Stockholm City Arts Council (Stockholms Konstkansli) to choose 10 of the nominated sites for public designation with plaques.

5.6 Phase Three: Manifestation

Permanent designation for the sites was subsequently to prove prohibitive within the budget and timescale of the project. It is therefore easy to see the importance of new media technologies to the documentation and

dissemination of the project outcomes.

The project website was designed to both archive the process and outcomes of the project, and also as an interactive means of exploring the Sound Sanctuaries online. This interactive exploration took the form of a *Virtual Sound Map*, allowing an audience to gain an overview of the project sites through a web browser.

An Interactive Sound Installation was also proposed, designed and prototyped. This was also intended to take the form of a Virtual Sound Map, this time within the three-dimensional space of the gallery. The InterActors would thus move around and explore the virtually mapped space, intended to be rigged with a series of triggers to allow interaction with sounds derived from the documentation of the project sites.

Similar to the other practical installations, this work was to be highly staged, with the aim of sublimating the technological nature of the space in order to give the impression that the audience was moving through an ‘organic’ environment, albeit one that is mediated by technology.

5.6.1 Brief Description of an Installation Prototype

The InterActor enters a darkened gallery space, filled with a light mist created by theatrical smoke machines. The sound material of the piece is derived from binaural and stereo recordings of the ten sound sanctuary sites across the city. A specially constructed digital audio playback system, consisting of 20 independent output channels is linked to a theatrical lighting rig installed in the gallery ceiling. This is computer-controlled to fill the space, at intervals, with pools of light.

Each InterActor is provided with infra-red cordless headphones, each pair with a flashing LED on the headband so that they are visible in the darkness. By walking towards and standing in one of the pools of light, the sound of one of the corresponding sanctuaries is heard in the headphones, until the light goes out and the sound ceases. The InterActors are thus taken on a journey around the space, following luminescent pools, exploring the sounds of the sanctuaries that appear in their headphones from the aether.

5.7 Summary

The above represents a discussion of aspects of the creation and development of the *Stockholm Sound Sanctuaries* project. Supplementary

material can be found on the Interactive Agents website, at <http://www.interactiveagents.com/soundscape.html> where, amongst other information, a database containing documentation of the nominated sites was posted in summer 2005. It should be clear from the above that this work not only raises awareness of the need for quieter environments, but also creates a forum for discussion and reflection of the local soundscape by those that experience it on a daily basis. As a creative artist, the focus of one's work is taken away from issues such as self-expression and the exploration of one's own responses to the sound environment. The role of the artist in terms of this project is to receive assignments to document certain locations from the participants and to systematically carry out this work.

It is precisely in this re-casting of the artist as conduit rather than creator in relation to material and processes, that the aims of the project were met: creating a living, evolving mapping process of some of the sonic spaces of the city and going some way to encouraging its inhabitants to choose their own sound sanctuaries for themselves.

Chapter 6 The Heliosonic Resonator



This chapter is accompanied by video documentation of the interactive sound installation *The Heliosonic Resonator* (2007) on the accompanying DVD.

Video documentation of the work taken at the Interactive Agents exhibition *Radioworks*, SHUNT Vaults, London, May 2007.

“Four hundred years after Kepler discovered his third law of planetary motion, disproving the Pythagorean notion of ‘the music of the spheres’, music was discovered in the Sun” (Chaplin, 2006)

6.1 Introduction

The Heliosonic Resonator consists of a large suspended disc, fitted with low frequency sonic transducers and covered with approximately 34 square feet of gold leaf. The audio signal is derived from NASA's Solar and Heliospheric Observatory (SOHO) spacecraft, which monitors oscillations created by seismic disturbances in the Sun. This section explores the installation, its conception, construction and presentation and how these concerns relate to the present study.

The installation was created for the Radioworks exhibition in May 2007

and was first conceived as the final part of a possible triptych consisting of the other major installation works which form part of the practical portfolio that supports this thesis, namely *The Earth's 4.5 Billion Year Old Electronic Music Composition* (2002) and *The Hydro-Acoustic Big Bang Filter* (2003 – 07). All three of these works, although very different in their physical manifestations, share a certain commonality of concept, the facets of which can be expressed as: the creation of an immersive interactive environment, the presentation of sonic material derived from space research through the physical manifestation of techniques associated with music technologies (e.g. the physical analogue of a band pass filter as the structural basis of *The Hydro-Acoustic Big Bang Filter*). Each of these key aspects will be dealt with below in turn, and will form the basis of this consideration of the work.

In the physical realisation of this installation I was assisted by Philip Arnold who was responsible for the mechanical and structural integrity of the work and Dermot McGinley who designed and constructed the electronic control systems. Further discussion of this collaborative approach can be found in the introductory chapter of this thesis in section 1.9.

6.2 Mode of Interaction

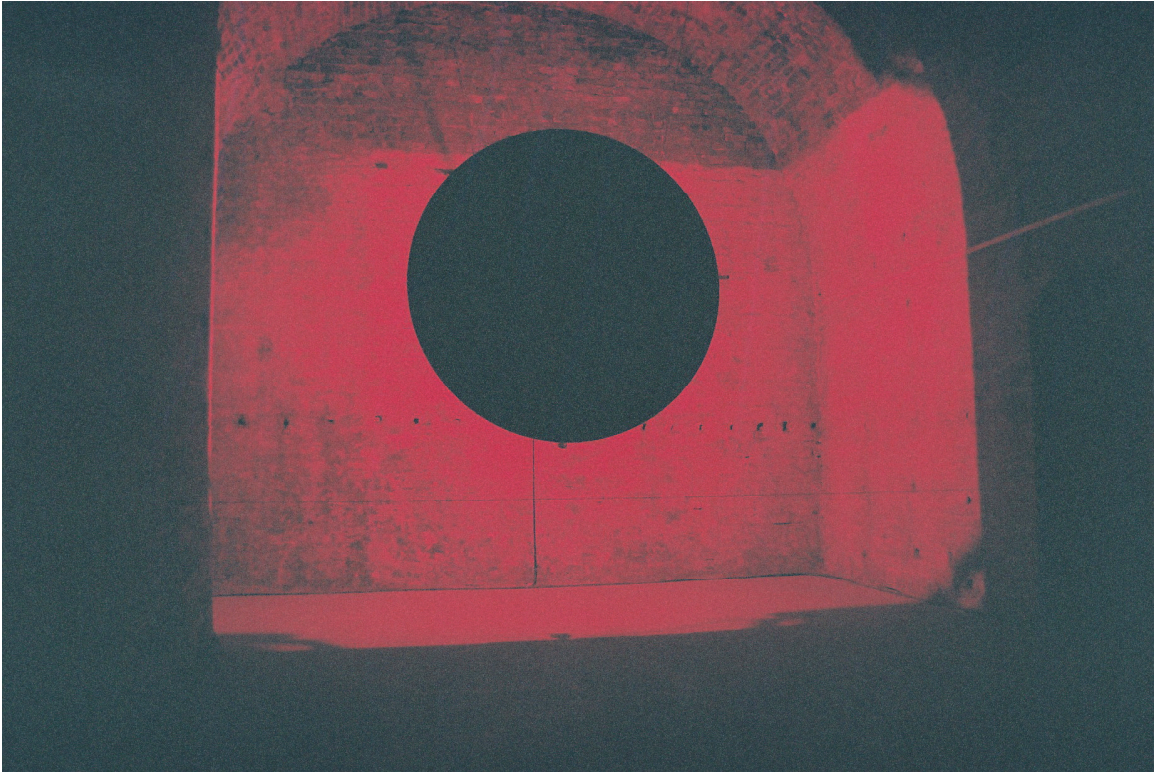


Fig. 6.1: *The Heliosonic Resonator* (Installation view) at SHUNT Vaults, May 2007. The installation in quiescent state.

The original conception for the mode of interaction in this work differs quite substantially from the other works mentioned above, in which the InterActor is encouraged to explore a physical space, triggering, and in many ways ‘playing’ sounds, creating unique structures from the material by physical presence or movement. This creates an open-ended situation where the InterActor controls temporal relationships and/or spectral characteristics of sound.

By contrast, *The Heliosonic Resonator* offers no such opportunities for sonic control. Instead, the function for the InterActor involves precipitating a vast and dramatic change of state within the installation and thus by extension the gallery space which surrounds it.

The quiescent state (as illustrated in Fig. 6.1) that confronts the InterActor as they first approach the work involves the 2 metre disc being silhouetted against the wall of the space by a wash of red light, provided by light fittings affixed to the reverse of the structure. Sonically, the sound stream is present at a very low dynamic level, experienced as a quiet, pulsating hum.

Given that the work is so closely associated with the Sun, this primary state was intended to give something of the impression of a solar eclipse, and it is this large, dark, vibrating mass within the darkened space which (it is anticipated) entices the InterActor to explore further and approach the installation. It is by approaching the object that the state change is activated, instantaneously effecting the dynamics of the audio system and activating the array of theatrical spotlights which are focused on the disc.

The active state is manifested by a rapid rise in the dynamic level of the sound material and the activation of the lighting system that dramatically illuminates the disc and suffuses the surrounding space with an intense golden light. This state change thus initiates an experience of the work characterised by its physicality, in terms of both light and sound. In the active state, the sound material is experienced as physical vibration within the body and within the acoustical properties of the space, and the lighting system reveals the luminescent nature of the disc.



Fig 6.2: *The Heliosonic Resonator* (Installation view) at SHUNT Vaults, May 2007. The installation in active state.

6.3 The Heartbeat of the Sun

“Nature has provided in the resonant modes of the Sun a wonderful tool with which to probe its interior. Many millions of modes of oscillation are supported . . . Each mode gives information on structure and rotation, through the layers its constituent sound waves traverse – and there are lots of modes probing a vast gamut of interior ranges. From the spectrum of solar-like modes it then becomes possible to re-construct a profile, literally a map of how properties like sound speed and density vary in the interior.” (Chaplin, W.J., 2006: 55-56)

Massive movements constantly taking place in the different layers of the Sun create seismic disturbances and it is these movements that give rise to the solar oscillations, that are used to create the sound material utilised in the work. This sound material was used with the permission of NASA and was created using data collected by the Solar and Heliospheric Observatory (SOHO) space probe, a collaborative project by NASA and the European Space Agency, launched in 1995, to further the study of helioseismology, the principle aims of which are defined as:

“ 1) the inference of the thermodynamic structure and 2) the inference of the dynamic motions of the solar interior as functions of both position in the Sun and of time. (Rhodes, E.J et. al., 1996)

The sound files are created by processing and analysing data from the Michelson Doppler Imager (MDI) instrument, developed jointly by the W.W. Hansen Experimental Physics Laboratory at Stanford University and

the Solar and Astrophysics Laboratory at Lockheed-Martin Advanced Technology Centre. The MDI continuously measures solar oscillations of a number of different types, including sub-sonic acoustic waves (referred to as *pressure* or *p-modes*). These are measured in terms of fluctuations in Doppler velocity (or Doppler shifts), and are essentially standing waves between the interior layers of the sun and the photosphere at the surface. (Kosovichev, A.G. et. al., 1996).

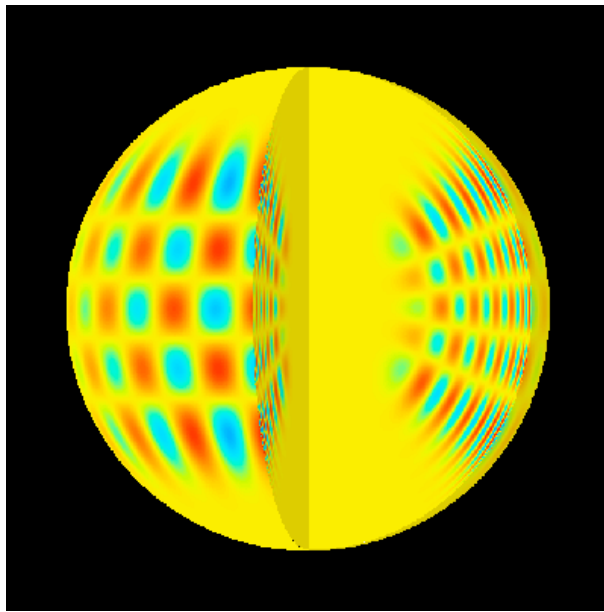


Fig.6.3: A computer generated image to represent acoustic oscillations (p modes) between the interior and the surface of the sun. “The frequency mode determined from MDI data is 2935.88 ± 0.02 microHertz” (Image Source: Kosovichev, A.G. et. al., 1996).

Figure 6.3 shows such an acoustic wave oscillation within the Sun. To give an idea of the frequency of such oscillations, 1 microHertz is equal to 1 millionth of a hertz, or 1 cycle every one million seconds, that is to say 1

cycle every 11 days. The example above is nearly 3,000 microHertz indicating a frequency of approx. 3.4 days. Given the nature of these subsonic frequencies, these waves have to be sped up by a factor of 42,000 to bring them into the human audible hearing range during the creation of the sound files²².

6.4 Creating the Resonator

As had been the case previously with *The Hydro-Acoustic Big Bang Filter*, the intention with this work was to create a physical analogue for a music technological process, allowing an audience the opportunity to experience, in a real world, tactile sense, a process or phenomenon that is usually sublimated in more common forms of electronic music presentation. Therefore, the work was always intended to be its own transducer: a large, vibrating body that takes on the properties of a di-polar radiator, effectively a loudspeaker without a baffle or cabinet.

²² An audio file of the kind used in the installation can be heard at http://www.gsfc.nasa.gov/gsfsc/spacesci/solarsounds/solarpics/3tones_245.mpg, with further examples available at http://www.gsfc.nasa.gov/gsfsc/spacesci/solarsounds/solarpics/3tones_245.mpg

This idea was modified somewhat in development, as the concept went through many convolutions and was originally to be realised by utilising a large orchestral tam-tam, to the back of which was to be fixed a tactile transducer, with the harmonics generated by passing the Heliosonic sound stream through the instrument definitively colouring the resultant sound of the work.

There was also much discussion regarding the nature of interaction to be used. In an early design, the tam-tam was to be suspended horizontally and the InterActor was to be encouraged to actually touch the work, thereby triggering the state change, and ensuring an extraordinarily tactile encounter with the work, as sonic vibrations are not only heard but also enter the body through the hands.

However, it was finally decided that to purchase a tam-tam, only to render it unusable by drilling it and affixing electronics was perhaps not the best approach and concerns were also raised that the use of such an instrument would constrain the scale of the structure and therefore possibly the impact of the installation.

To ensure that the visceral experience of sound was still part of the piece, an increased amount of power was incorporated into the design to allow the sonic energy to traverse the atmospheric void between device and the InterActor. Accordingly, a new configuration was proposed comprising four closely situated transducers mounted upon an open baffle. It can be seen that the transducer arrangement is no longer the source of harmonics and is therefore required to simply perform the role of a conventional dipole radiator manifested as an open baffle or doublet arrangement. Implicit in this is the requirement to be as acoustically inert as possible and therefore structurally rigid and mechanically damped.

The relationship between the rear wall and the Resonator provides a half-space acoustic loading for the device and the resultant rear wave reflections combine with the directly radiated wave front to produce a low-frequency comb filter. The nodal and anti-nodal interactions of the two wave fronts combine to lend an entirely new timbral quality to the sound.

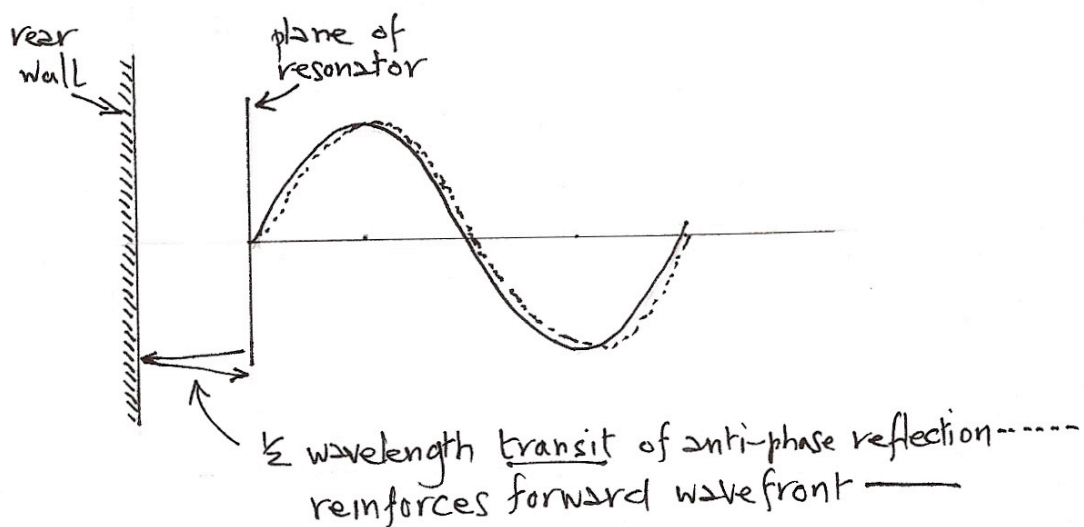
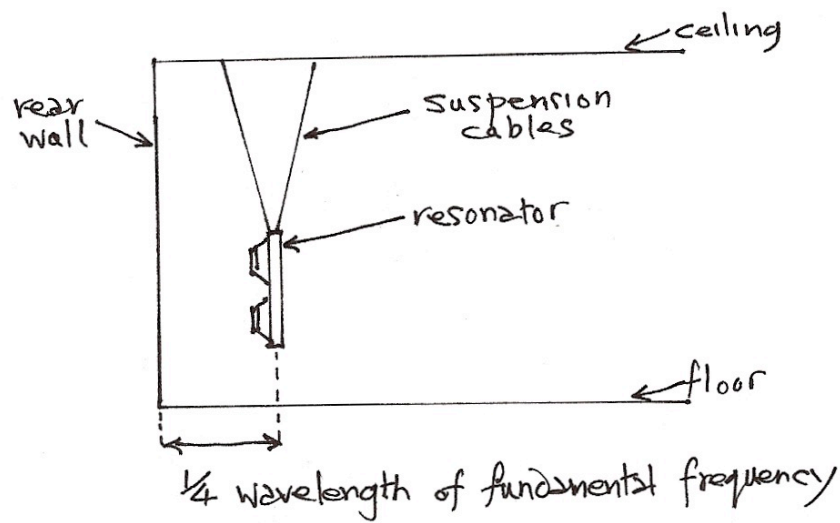


Fig. 6.4: *The Heliosonic Resonator* (2007) Acoustic Arrangement.

Further harmonic colour is lent to the proceedings by the excitation of the structural fabric of the exhibition space; for example doors will absorb a

certain amount of acoustic energy, subsequently releasing it as spurious manifestations of the original signal. Although a very large amount of acoustic energy is required to do this, the resultant effect envelops the InterActor in a harmonically resonant cacophony, placing them right at the heart of this real-world synthesiser.

The foundation of *The Heliosonic Resonator* as it now exists is fundamentally formed from a composite chassis realised as an MDF disc two metres in diameter. This is reinforced by a galvanised steel sub-chassis supporting both the flying hardware for the steel cable terminations and also the 1-kilowatt custom-built amplification system.

Four high-sensitivity sonic transducers are mounted to the chassis in a geometric configuration to maximise the low frequency output. This configuration of chassis and transducers has a capability to exceed 120 decibels of sound level at one metre from the face of the work within the second octave (40hz – 80hz).

Evenly tensioned across the front fascia of the Resonator is a cotton substrate membrane, providing the foundation for the gold leaf finished surface. It was important that the combination of substrate, gold leaf and

polyurethane sealant was applied in such a way as to maximise sonic transparency. The use of polyurethane provided an essential protective layer for the fragile gold leaf surface whilst also mechanically bonding it to the substrate membrane to maximise resistance against the high sound pressure levels during the active state.

The custom-built kilowatt amplification system is based on high-current MOSFET technology to ensure the undistorted delivery of the low frequency transients present in the source material.

Once the 250 kilogram work is in its installed position, suspended by the use of high-tensile stainless steel cables, the passive infra-red detection system is then installed and calibrated on the lower edge of the main chassis. Once powered, this device continuously monitors the floor area immediately in front of the work for InterActors to trigger the piece.

On detection of a thermal signature by the PIR detector affixed to the work's bottom edge, the system is switched from its quiescent to its active state. This change of mode initiates a dual programme of sonic and ocular stimulation. As the sound level increases by several orders of magnitude the

theatrical lighting system is energised, thereby reinforcing the dramatic impact.

After a pre-set time period, the installation switches back to its quiescent state, returning the InterActor to a more subdued environment. At anytime, however, the work can be re-triggered into its active state.

6.5 Gilding the Resonator

The luminescent quality of the surface was an important consideration, and a number of solutions were suggested for how this was to be achieved. The first attempt involved the use of a water-based gold paint but this had nowhere near the required amount of luminescence. The decision was finally taken to use gold leaf, as it was felt this would give the desired effect of limbic stimulation when theatrically lit and given its high reflectivity, would engulf the immediate vicinity in a golden glow during the active state.

One thousand sheets of 15 x 15 cm gold leaf were purchased and

applied, layer upon layer onto the paint-primed cotton membrane²³. The surface I had envisaged for the work was extremely textured and volatile, having been suggested in part by photographs of the surface of the Sun taken by the on-board camera system of the SOHO space probe (see fig. 6.5). Applying layer upon layer of gold leaf achieved the resultant textured surface, which reacted exceptionally well when theatrically lit.

²³ It was during this lengthy period of application that I was reminded of Yves Klein's Monogold pieces from that late 1950s and early 1960s, such as *MG 18*, 1961. These large monochrome works were realised (I was to discover later) by covering large wooden panels with cotton fabric and then applying pigment and gold leaf, a technique bearing a certain adjacency to that used in the creation of this work.

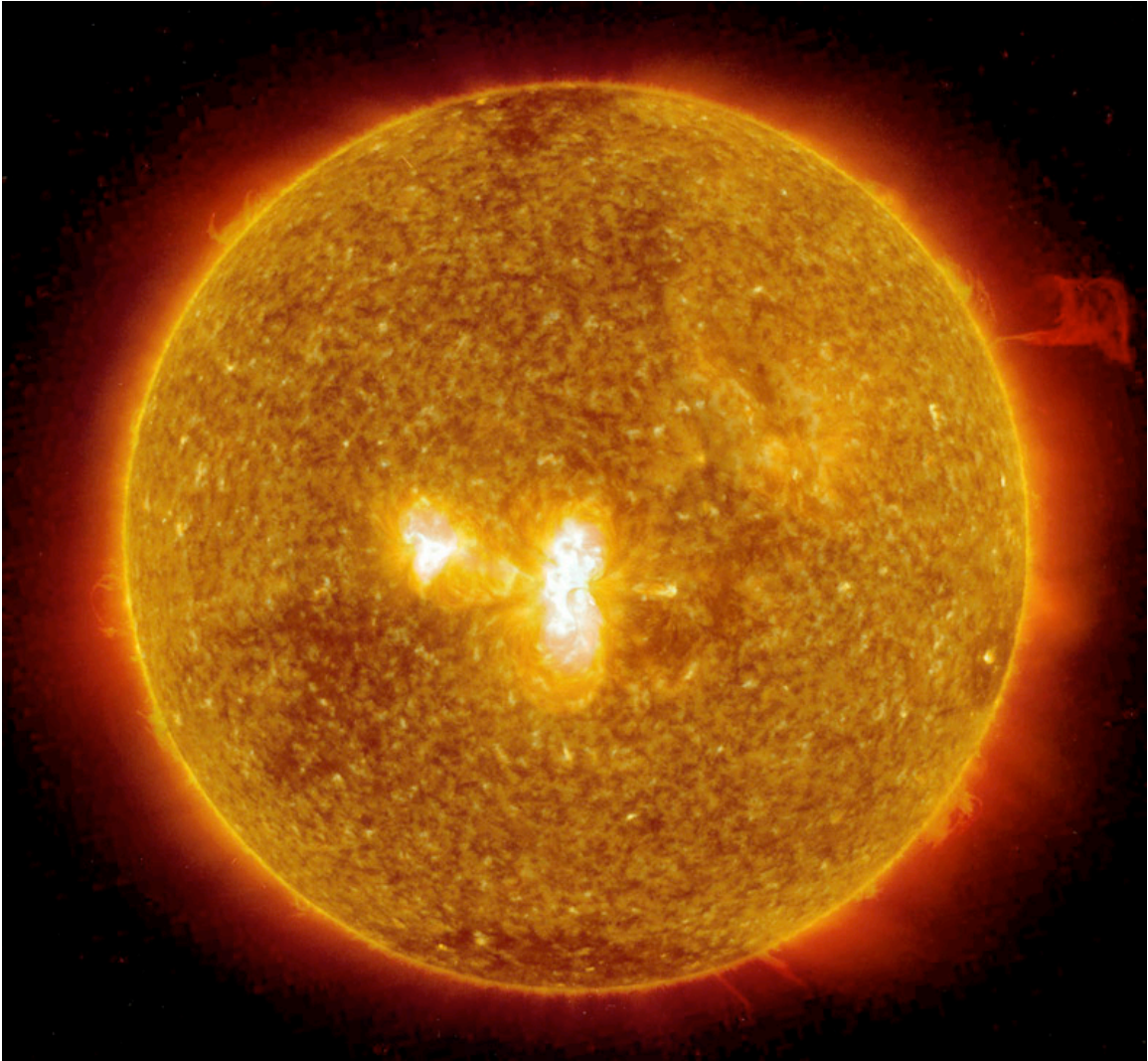


Fig. 6.5: A composite photograph of the surface of the Sun taken by the on-board camera system of the NASA/ESA SOHO space probe. (NASA, 2008)

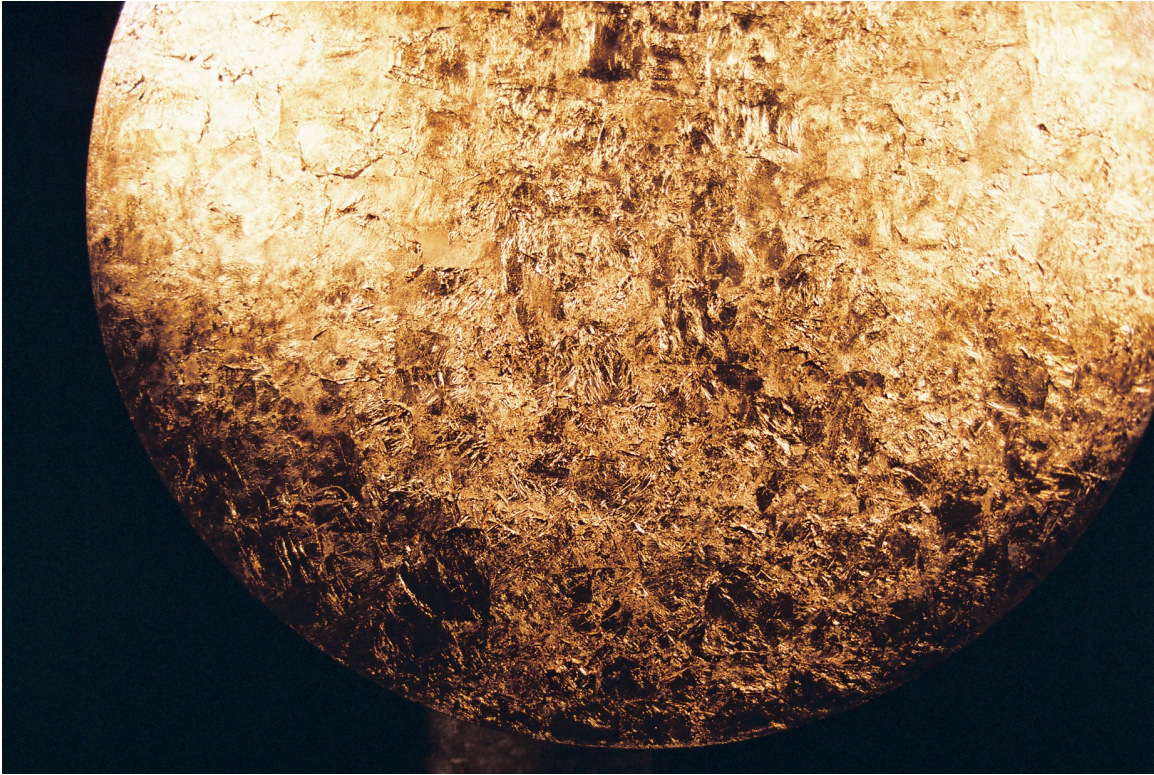


Fig.6.6: A close-up of the surface of *The Heliosonic Resonator*, showing the highly textured surface of the work.

6.6 Summary

Similar to the other large-scale installation works in the portfolio, *The Heliosonic Resonator* was developed from the interplay of concepts and approaches from a radically disparate array of disciplines and research fields. At once extending the outcomes of leading-edge space science research into the realm of art, the work again highlights the application of audio technologies by scientists in the acquisition of new knowledge regarding celestial operations.

In the use of gold leaf the work references techniques known to ancient civilisations, as a means of representing the Sun, a connection which has been made since the earliest of times. The installation harnesses these considerations to wider industrial and fabrication research to facilitate its construction and realisation.

It is this synthesis of ideas that, it is hoped, gives the work its conceptual vibrancy. A vibrancy matched by physical experience, as an InterActor moves forward to initiate the dramatic state change and encounter the primordial sounds of solar oscillations, literally ‘the music of the Sun’.

Chapter 7 Conclusions

From the outset this study was intended to be a contribution in terms of practice-based research and thus it is fitting that any conclusions that are drawn should be embodied, in the first instance, by the practical works. The opening part of this section shall therefore involve the major installations, their presentation and reception. This concluding section is concerned with the drawing together of many of the issues examined in the preceding chapters, whilst also discussing the development of an exhibition that provided an important presentation opportunity for the three main interactive sound installations associated with this thesis. This represented a decisive step in the progress of this research, as it is only with public presentation that the success and validity of theoretical and practical constructs can be fully assessed.

7.1 The Development of the Exhibition



Fig. 7.1: Promotional logo for the Radioworks Exhibition

The exhibition, entitled *Radioworks: New Directions in Sound Art* by *Interactive Agents*, opened on 1st May 2007 at SHUNT Vaults, a vast 70,000 square foot network of railway arches under London Bridge Station. The venue had formerly been a bonded wine vault for some 200 years until 2005 when it was leased to SHUNT, a theatre company formed by the collaboration of 10 artists who specialise in the creation of site-specific performance events in disused industrial spaces across London. During 2006-2007 the current event was the SHUNT Lounge, a bar deep within the

subterranean tunnels of the vaults, with a changing programme of events including performance, installation, music and film. The Radioworks exhibition formed part of this initiative for the period of three weeks.

This choice of venue was the culmination of more than a year and a half of negotiations with venues, curators, producers and administrators, in an attempt to secure a showing of these large-scale works, but with little success. This was due to a variety of reasons, including the fact that most artist-run galleries and spaces had neither the headroom or floor space to accommodate work on this scale and most major (or commercial) spaces were either unable or unwilling to provide space for work that was unknown, untried and (at that time) mostly unrealised. Many spaces also felt that this work was not encompassed by their curatorial profile, or had their artistic programmes planned as much as two years in advance, placing any possibility of exhibition outside the window I required for the completion of the practical documentation to accompany this thesis.

By summer 2006, I was more or less resigned to the fact that if I were to achieve a showing of these works in the short term, ideally in a central London venue of the size required, it would necessitate private hire. I

therefore changed my approach to take this into account. It was in September 2006 that SHUNT Vaults was suggested to me as a possibility by Manick Govinda of Artsadmin, an East London-based artists consultancy service. Negotiations began that month with the venue and an agreement was in place for the showing in May 2007 shortly afterwards.

The venue turned out to be ideal for the requirements of the show. Firstly, there was an abundance of space, allowing the exhibits to be properly situated and installed without crowding each other. Furthermore, the long corridor (which led into the venue through a small, anonymous doorway opposite the Joiner Street entrance of London Bridge underground station) was formed by a series of opposing archways, further accentuating this separation, whilst minimising overspill of sound from what are sonically quite distinct pieces.



Fig. 7.2: The Long Corridor at SHUNT Vaults, under London Bridge Station, SE1.

Secondly, as the space was underground it offered a very high level of control with respect to lighting. Each work was thus revisited in turn and fitted with intrinsic lighting systems, as can be seen from the final photographs in each of the chapters of this thesis concerning the installations. In each case this added a new dimension to the works in terms of their presence and dramatic effect.

Thirdly, since this was an alternative venue, the audience attracted was

perhaps broader than it may have been had the works been shown in a more normal gallery context. The exhibition was also only open in the evenings, at the same time as the bar, so the audience on a given night could be made up of a combination of the public, the arts crowd, experimental/electronic music aficionados, students, a fairly large contingent of workers from the nearby City of London and others who formed a constant stream of passing trade, intrigued as to what was going on behind this mysterious door on a busy thoroughfare opposite the tube station.

Once the decision on exhibition venue had been made, the work began on preparing the exhibits in earnest. In essence, this involved re-commissioning *The Earth's 4.5 Billion Year Old Electronic Music Composition*, finishing the design and building of the second version of *The Hydro-Acoustic Big Bang Filter* and conceiving, designing and building a completely new work that became *The Heliosonic Resonator*.

Creating art of this scale presents constant challenges, aside from those regarding exhibition opportunities mentioned above. Creation and construction is extremely space intensive and the use of an industrial unit was required for this purpose. Transportation to London Bridge from the

workshop in rural Hertfordshire required a succession of long wheel base transit vans and 7.5 ton trucks with tail lifts, together with a series of complex strategies for loading these large, but often delicate, works into vehicles without damage.

Loading into the venue was likewise problematic as, given the age of the building, careful negotiation was required by modern vehicles with respect to entrances that had been designed with a horse and cart in mind. In all, it took a team of three people (the Interactive Agents) nearly nine days to construct the exhibition, with the final preparations being made with only a short amount of time to spare before the opening.

The layout of the exhibition can be seen in fig. 7.3, with each exhibit occupying a designated archway, distributed along the whole length of the long corridor. The rationale for this was partially to highlight the different modes of interaction inherent in the works, but also to minimise considerations such as sonic interference.

7.2 Exhibition Layout

The exhibition opened with *The Heliosonic Resonator*, as this afforded an extremely dramatic introduction. After this the InterActor moved down the corridor and was confronted with *The Earth's 4.5 Billion Year Old Electronic Music Composition*, where the mode of interaction is more subtle, as one becomes aware that one's movement and physical presence is effecting the operation of the artwork, though perhaps not in an obvious way. Finally, at the bottom of the corridor, the InterActor finds *The Hydro-Acoustic Big Bang Filter*, which has the most active and intuitive interface of the whole show.

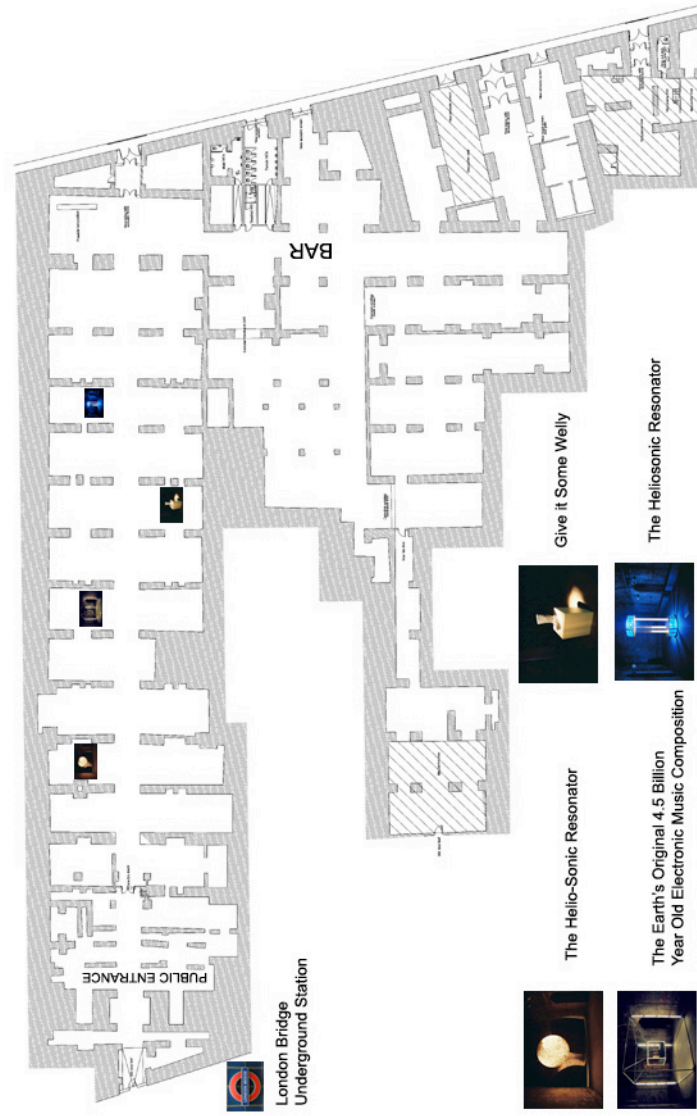


Fig.7.3: Plan of the layout of the Radioworks Exhibition at SHUNT Vaults, May 2007.
This plan also gives an indication of the size of the venue.

The only exhibit not mentioned so far (essentially because it does not form part of the practical portfolio) is *Give it Some Welly*, a ‘prepared’ Wellington boot, created as a humorous contribution to Fylkingen’s 70th anniversary celebrations and first shown at Kulturhuset, Stockholm in 2003. *Give it Some Welly* contains a pseudo-randomised playback device with one of eight possible outcomes, triggered by an auto-biasing shadow-sensing circuit. When the enquiring InterActor casts a shadow over the top of the welly, it emits one of the pre-recorded messages, normally instructing them, in no uncertain terms, to make their way to the egress!



Fig.7.4: *Give it Some Welly* (2003) by Interactive Agents.
‘Prepared’ Wellington boot with semi-intelligent vocal reciprocation system.
Installation view at Radioworks Exhibition, SHUNT Vaults, May 2007.

In the Radioworks exhibition, *Give it Some Welly* offered some light relief, situated in an archway between the last two exhibits.

7.3 Audience Reaction

“Existing approaches to studying the relationship of audiences to interactivity can be grouped in two categories. The first comes from a traditional museological approach and focuses on education and interpretation. The second comes from the field of human-computer interaction and offers a new perspective on the understanding of interactivity.” (Muller, L. and Edwards, E., 2006).

The theoretical basis for the following discussion of how the audience reaction to the practical works was observed during the exhibition can be found in the introductory chapter of this thesis dealing with the nature of the interactive systems explored in the portfolio and the definition of the role of the InterActor. Once the premises for this analytical approach have been established, I shall deal with each exhibit in turn, outlining how audience reaction manifested itself, how observed reactions compare with original intentions for the user interface specifically developed for each work and finally how audience response to these exhibits may be fed back into the creative process. This could either entail modifications to the present artworks for future showings, or the effect that audience research has on the

approach Interactive Agents uses in the creation of new artworks, including such considerations as interface design, presentational strategy or projected user experience.

In the above quote Muller and Edwards, two members of the Creativity and Cognition Studios at the University of Sydney delineate (as they see it) the two main areas of audience research as it pertains to interactive artwork. Framing the analysis of audience response from a museological point of view may indeed be useful, as this considers the transference of information and meaning with regard to curatorial practice and audience behaviour in gallery and exhibition contexts.

However, to frame the consumption of interactive art in terms of human-computer interaction is exactly the kind of notion that these artworks were created to refute. Such an approach surely tells one more about how humans react to computer systems than the multiplicity of reactions they can have to art. It also highlights one of the main aspects that this research has reacted against: the fact that (perhaps wrongly) interactive art still for the most part denotes computer-based artforms.

The very existence of the works under discussion here supports the existence of a technologically interactive artform without recourse to computational norms and standardised (or commercial) concepts of interface design. A key factor in the intention and reception of this exhibition was that the InterActor encounters the artworks on their own terms, rather than being pre-conditioned by their everyday experience of more familiar technological interfaces.

To this end, a series of curatorial decisions became necessary. This involved not only the layout of the exhibition as outlined above, but also that very little information was to be given in the wall-mounted descriptions that accompanied each work about how one interacts with the installation or any explicit instructions on the discovery of the interface.

Therefore a degree of curiosity and experimentation was required from InterActors if they were to fully experience the work. This lack of information is, of course, a double-edged sword, as a certain percentage of the audience would pass the exhibits without engagement, or in certain cases read the wall-mounted text, pause to view the artwork and move on, in a typical enactment of accepted gallery audience praxis. This situation could

often be overcome, however, by a potential InterActor following the example of others, either gallery invigilators or other InterActors.

This slightly oblique approach to audience instruction also informed the methods used in assessing audience reaction. Any kind of obvious approach, such as audience questionnaires or formal interviews would have compromised what was a carefully managed presentational strategy involving the interplay of sound, light and interface. Any heavy-handed attempts at measurement or metrication of the experience would have been too intrusive on the overall dynamic of the situation and thus definitively coloured any such measurement or resultant data collected.

The approach taken involved the three artists acting as gallery invigilators for the entire period that the public had access to the exhibition, therefore being well placed to observe audience activity and response throughout. Gaining an impression and drawing conclusions as to which exhibits were most successful in terms of response and a general sense of the impact of the show as a whole.

The role of invigilator frequently included subtle interactions with audience members, sometimes to encourage engagement with an artwork by example, or to answer questions and generally discuss the work. Any more

apparent engagement was felt to be inappropriate for the show, especially given the fact that it was taking place in an alternative venue. The last thing you want people to feel on a night out is that they are inside some kind of social science experiment or market research initiative.

There now follows a consideration of each exhibit in turn, offering observations, speculations and analyses of audience activity and response. These observations are also supported by video documentation, edited versions of which can be found on the DVD that accompanies this thesis.

7.4 Audience Response: *The Heliosonic Resonator*

Due to the relatively low ambient sound and light levels of this work in its quiescent state and considering it was the first exhibit in the show, this work was perhaps the one that a number of people tended to miss the first time they passed its archway. The subdued eclipse effect of a black disc in red light was not always fully discernable on first viewing. The sensor fitted to the base of the installations chassis was also calibrated so that an InterActor would have to move about two thirds of the way into the archway, quite close to the safety wire, to trigger the work. This work was therefore designed especially for those with a keen sense of curiosity.



Fig 7.5: InterActors with *The Heliosonic Resonator*, SHUNT Vaults, May 2007.

Once triggered, the combination of the intensity of the sound material, the vivid golden light and textured surface of the disc was extremely dramatic and had exactly the desired effect on most InterActors. Many commented that their experience of the sound was especially visceral in nature. The physicality of this sound was due in part to the sheer amount of low frequency energy emanating from the artifact and the effect this had on the

immediate acoustic space, exciting doors and light fittings and the like. The sound also had a marked effect inside the human body, inasmuch as that it was at, or near, the resonant frequency of the human vocal chords. Many people remarked upon the effect the piece had on the speaking voice when situated directly in front of it. Remarks were also made regarding vibrational sensations in other parts of the body, including the chest cavity.

All mammals are particularly attuned to low frequency phenomena, which (before we were able to create them with loudspeakers) are associated in nature with danger and certain large-scale natural forces such as earthquakes and volcanic eruptions. Therefore, experience of this work may have precipitated a heightened state of adrenal stimulation. In any case the powerful nature of the experience was designed to give an inclination of forces of the order of the oscillations from which the sound is derived.

As was the case with the other works in the show the extent to which InterActors fully read the wall-mounted descriptions, offering explanations of the associated science and artistic objectives is unclear. Many did and thus gained a fuller contextual understanding of the works; others chose to approach an exhibit on a purely experiential level, directly experimenting

with the interface, without its more cerebral or conceptual aspects. Both levels of experience were fine from the point of view of artistic intention. An important design consideration in each of the installations was that they operated equally well with differing levels of engagement, with uninformed experience as equally valid and in no way detracting from enjoyment of a work.

Once *The Heliosonic Resonator* had been triggered and returned to quiescent state, the likelihood of re-triggering by an individual or group of InterActors was fairly high. I also recall, late one Friday night, one group who stood before the work for an extremely long time, as if transfixed by the spectacle. In that vaulted archway, there was something almost ritualistic in nature of these particular shadowy figures in relation to the work.

As a result of the venue's relaxed attitude towards photography (and, of course, the ubiquity of a certain species of mobile technology) there was a high percentage of InterActors who took pictures (still and video) of the works and *The Heliosonic Resonator* was a very popular candidate for this, either photographed on its own, or with parties of InterActors posing in front of it.

The work was designed and installed so that a large amount of golden light, reflected from the disc, would spill from the archway and be seen all the way along the corridor. This effect was very successful and also encouraged those who may have missed the work the first time to return and inspect the vibrating disc a little closer.

7.5 Audience Response: *The Earth's 4.5 Billion Year Old Electronic Music Composition*

As the only work in the exhibition to have been shown on two occasions previously, some preliminary information existed regarding audience response and behaviour. However, the manner of presentation at this event was very much different from previously, with a darkened space and additional lighting effects and this had a definite effect on audience reaction. This work has the most subtle mode of interaction of the three main installations and is also the only one to have an intrinsic spatial element in terms of the large steel cube. This was brought into sharper relief at this showing by strip lighting in the uprights of the large cube.

Some people appeared reticent to actually enter the space frame on first encounter. This may have been an overhang from the received gallery practice of not approaching, or stepping inside artworks unless expressly directed. This response may have also been instigated by reading the background information that discusses high-voltage electromagnetic discharges, which may have made InterActors slightly wary of crossing the threshold of this dazzling steel structure, evidently alive with electricity. At times an invigilator would have to demonstrate the manner of operation, often by simply walking into the space, rather than by verbal instruction.

Many InterActors reported that they could not precisely locate from where in the structure the sounds were emanating. Again, this was intentional, owing to the spatial arrangement of the loudspeakers, with the sub-woofer housed within the central plinth and the four satellite speakers situated at the top corners of the main cube.

In this context audience response was perhaps not as immediately enthusiastic as it was for some of the other works in the show. Although once InterActors had realised that their movement and physical presence triggered sonic events, many people began experimenting with speed of

perambulation or sporadic concentration of physical movement. Some more observant individuals noticed the PIR detectors located beneath the central plinth and would begin gesturing towards those as a means of triggering sounds.

This work was unique in the exhibition as it is the only one with an overtly recognisable technological artifact: the antique radio. This has always been an important signifier in the piece, presenting the idea of ‘radio’, thus tying in with the VLF emissions within the sonic material. Once again, some were wary of touching this object at first, while others enjoyed the opportunity to experiment with the sounds generated by manipulating the tuning dials. Certain other InterActors discovered a further dimension of sonic interaction in the work by effecting the radio output by hand gestures in front of the speaker grille²⁴.

²⁴ This was an unintentional consequence of the presentation situation and not part of the design. It was due to elements of stray capacitance and inductance effecting the tuning circuit of the radio, induced by the close proximity of the InterActor’s hand.

7.6 Audience Response: *The Hydro-Acoustic Big Bang Filter*



Fig.7.6: InterActors with The Hydro-Acoustic Big Bang Filter, SHUNT Vaults, May 2007.

The undoubted star of the show, *The Hydro-Acoustic Big Bang Filter* was certainly the most popular from the perspective of audience response to physical form and interface. This offered highly engaging, direct and unambiguous control possibilities over the flow of water through gestures of the hand, which many found particularly satisfying. Many InterActors spent a considerable amount of time experimenting with this work.

The exact nature of the interface was not always apparent on first approach, with many InterActors not noticing the sensors or being aware

that operating the work involved breaking beams. Thus a whole repertoire of different interaction strategies developed, some involving physical contact with the hydro-stanchions, while others would follow the meniscus up and down the tube with the hand, or place their hands directly on the sensors or reflectors to achieve activation. In most of these cases the InterActor would intercept the beam creating the desired effect, so all of these approaches worked equally well. On a few isolated occasions (usually later in the evening) an over-zealous InterActor would actually climb into the structure and engage in what can only be described as a kind of ‘pole-dancing’ activity. These individuals were promptly asked by a member of the Interactive Agents team to refrain from such action.

The installation operated as a remarkable social nexus, possibly because of the physical arrangement of the hydro-stanchions, encouraging InterActors to observe each other through the machine itself, engaging in social interaction, often non-verbally, perhaps only a glance or a smile. From a certain perspective the installation also offered a microcosmic model of social development, as once the stage of learning the interface had been accomplished, many began to take ownership of the experience by demonstrating it to others. Some would return to the piece on separate

occasions and demonstrate it to friends. At times, groups of individuals would engage in races to see who could fill their hydro-stanchion the fastest²⁵. This work was also, by some margin, the most photographed of the collection.



Fig.7.7: An errant pole-dancer shortly before being asked to refrain from such activity, SHUNT Vaults, May 2007.

The Hydro-Acoustic Big Bang Filter was always designed with this element of play in mind and the analogy of a musical instrument in the wall-mounted description was an apt one. Certain individuals who were informed

²⁵ The manner in which this work especially (and the others to a greater or lesser extent) functioned as a mediator within transient social encounters between InterActors resembles Nicolas Bourriaud's influential concept of Relational Aesthetics (Bourriaud, 2002).

of such things likened the interface to that of the Theremin, although it became apparent that the sonic element of the work (which one will remember resembles broad-band noise) was perhaps not the main element of the work's attraction. This element did, however, successfully support the unusual spectacle of seeing water flowing upwards in the columns, together with the lighting of the structure, which encompassed the blue, slightly UV lighting in the works dormant state, shifting to the full lighting effects when activated.

Many found the visual form of the work pleasing. Several remarked on its similarity to the set of the Transporter Room from the 1960s *Star Trek* television series. In actual fact, this was a slightly intentional sci-fi aesthetical consideration that had been discussed during the design phase. Other InterActors remarked on the formal similarity to a lava lamp, another kitsch association that is equally amusing.

To gauge the relationship of sonic to visual effectiveness we began experimenting with varying the dynamic level of sonic output to see what effect this would have on audience attraction or response. For the most part it was found to have very little effect on demonstrable engagement with the

piece, even at low sound levels.

The somewhat visible technological components (pumping system in the base and audio system in the upper layer), partially obscured behind stainless steel mesh encouraged a certain amount of debate as to how the installation worked. The calibration of the hydro-stanchions so that the water seemed to disappear into the upper layer, while the pump system remained energised added to this apparent mystery, another factor in the complex and diverse range of responses that this highly successful and popular piece provoked.

7.7 Summary

The central aim of this research has been the creation and synthesis of a composite artistic practice from the underlying principles, namely experimental sound art, interactive systems and soundscape research. The writing of this thesis presented a valuable opportunity to consider a range of theoretical and contextual perspectives drawn directly from issues represented by and dealt with in the practical portfolio as the basis for considering and documenting the development of the works themselves.

Throughout this process of development I became increasingly aware that a transformation was indeed taking place. This is evidenced by the fact that my discussion of this work now rarely focuses on the relationship of isolated elements, but rather on what the work has become and now signifies: the blueprints of an innovative artistic approach which has its own identity, its own frames of reference, whilst drawing sustenance from a fusion and integration of existing disciplines.

In re-reading the above descriptions of audience response, it is noticeable that when describing an aspect of a given work in relation to one of the original principles, I am simultaneously referencing facets of many of the others. Sound, interaction, technology, nature, science and the visual arts combine with an effervescence and ease of movement, which is the result of long-term engagement with theoretical and conceptual issues as the basis of practical work. This ability to navigate through a constellation of ideas and working practices must surely be a key aspiration of any interdisciplinary research.

The developmental trajectory of this approach can be found throughout the entire project: from its original intentions of creative

engagement with recorded material derived from the sound environment within the electro-acoustic music studio, which was gradually expanded into the realm of interactive sound art with the creation of the first major installation work in 2002. This work was pivotal, as it also introduced another of the main themes of this research, being the extension of space radio phenomena into an artistic context which, in later installations, encompassed the utilisation of data sonifications created by cosmologists and astrophysicists as the basis of interactive sound work.

The modes of public presentation of this artistic practice became increasingly important, especially since it gave rise to participatory artworks. I always intended from the outset that the practical outcomes from this research should be presented at the highest level that I could realise, thus maximising their impact. This is perhaps the reason why I spent so long considering potential exhibition strategies before formulating the approach finally taken. In the process one comes to the realisation that the task of situating one's research in the public domain is as much work as the research itself, or as artistic creation. At the end of a chapter mostly dealing with audience response, it is useful to remember that how an audience receives

the work is as much to do with how one frames it, as it is in the details of the art itself.

It now seems like a long time ago since the *Moonbounce* project, or the final concert I gave as an electro-acoustic composer at Fylkingen in 2001. The disenfranchisement that I felt with certain aspects of creation and performance as it was then practiced, directly gave rise to the current study. As these artworks are re-shown, together with others that will likely follow, the aim now is as it was at the beginning: that the technologically-based sonic artworks, participatory and inclusive in nature, described herein may leap from these pages and become a (non-virtual) reality.

Bibliography

AMMOT (2003). *Lyssna till vad du hör*. (Stockholm: Konsumentverket)

Armstrong R. (1995). *Sci-Fi Aesthetics*. (London: Academy Group Ltd.).

Arp, J. (1948). *On My Way: Poetry and Essays 1912 – 1947*. (New York: The Documents of Modern Art).

Bandt, R. (2001). *Sound Sculpture: Intersections in Sound and Sculpture in Australian Artworks*. (Sydney: Fine Arts Press).

Bishop, C. (2005). *Installation Art: A Critical History*. (London: Tate Publishing).

Bliss, A. (2008). *None Shall Pass: An Interview with Philip Jeck*. [WWW] Available at:

http://www.touchmusic.org.uk/archives/reviews_philipjeck/planb1.jpg

[Accessed 24/11/2008]

Bongers, B. (2000). *Physical Interfaces in the Electronic Arts: Interaction Theory and Interfacing Techniques for Real-Time Performance*. In Wanderley, M.M and Battier, M. (eds.) *Trends in Gestural Control in Music*. (Paris: IRCAM/Centre Pompidou).

Boulter, J.D. and Grusin, R. (2000). *Remediation: Understanding New Media*. (Cambridge, MA: MIT Press).

Bourriaud, N. (2002). *Relational Aesthetics*. (Paris: Les Presses du Réel).

Bourriaud, N. (2005). *Postproduction: Art as Screenplay: How Art Reprogrammes the World* (2nd Ed.). (New York: Lukas and Sternberg).

Brooke, H. (ed.) (2002). *Retrofuturism: The Car Design of J Mays*. [exhibition catalogue] (Los Angeles, CA: Museum of Contemporary Art).

Bullivant, L. (2005). *Sky Ear*, Usman Haque. *Architectural Design*, 75 (1): 8–11.

Bullivant, L. (2006). *Responsive Environments: Architecture, Art and Design*. (London: V&A Publications).

Bullivant, L. (ed.) (2007). *4dSocial: Interactive Design Environments*. *Architectural Design*, 77 (4).

Burke, B.F. (1997) *An Introduction to Radio Astronomy*. (Cambridge: Cambridge University Press).

Campbell, J. (1996). Artist's Statement. [WWW] Available at <http://vv.arts.ucla.edu/terminals/t1/ucsc/campbell/campbell.html> [Accessed 24/11/2008]

Chaplin, W.J. (2006). *Music of the Sun: The Story of Helioseismology*. (Oxford: Oneworld Publications).

Cox, C. and Warner, D.(eds.) (2004). *Audio Culture: Readings in Modern Music*. (New York: Continuum).

Cramer, J.G. (2003). *The Sound of the Big Bang*. [WWW] Available at: <http://faculty.washington.edu/jcramer/BBSound.html> [Accessed 24/11/2008]

Cusack, P. (2001). *Your Favourite London Sounds*. [audio recording] RESFLS1CD. (London: London Musician's Collective).

Davis, E. (1998). *TechGnosis: Myth, Magic and Mysticism in the Age of Information*. (London: Serpent's Tail).

De Oliveira, N., Oxley, N. and Petry, M. (1994). *Installation Art*. (London: Thames and Hudson).

De Oliveira, N., Oxley, N. and Petry, M. (2003). *Installation Art in the New Millenium*. (London: Thames and Hudson).

Disinformation. (1996). *R&D [CD sleevenotes] ASH 2.9* (London: Ash International).

Dunne, A. (2005). *Hertzian Tales: Electronic Products, Aesthetic Experience, and Critical Design* (Cambridge, MA: MIT Press).

Duplaix, S. (ed.) (2004). *Sons et Lumières: Une histoire du son dans l'art du Xxe siècle*. (Paris: Centre George Pompidou).

Dzuverovic, L. and Neset, A.H. (eds.) (2005) *Her Noise*. [exhibition catalogue] (Newcastle upon Tyne: Forma Arts and Media Ltd).

Edge, R. and Petts, L. (1997). *The Collector's Guide to His Master's Voice and Nipper Souvenirs*. (London: The EMI Group).

Emmerson, S. (2007). *Living Electronic Music*. (Aldershot: Ashgate).

Ferguson, R. (ed.) (2003). *Christian Marclay*. (Los Angeles, CA: UCLA Hammer).

Gibson, W. (1984) *Neuromancer*. (London: Victor Gollancz)

Grayson, J. (ed.) (1975). *Sound Sculpture: A Collection of Essays by Artists surveying the Techniques and Future Directions of Sound Sculpture*. (Vancouver, B.C.: A.R.C. Publications).

Hatanaka, M. (ed.) (2000). *Sound Art – Sound as Media*. [exhibition catalogue] (Tokyo: NTT Intercommunication Centre).

Hatanaka, M. (ed.) (2003). *Sounding Spaces: 9 Sound Installations*. [exhibition catalogue] (Tokyo: NTT Intercommunication Centre).

Hayward, P. (ed.). (2004). *Off the Planet: Music, Sound and Science Fiction Cinema*. (Eastleigh: John Libbey).

Helliwell, R.A. (1993). *Whistlers and Related Ionospheric Phenomena*. (2nd Ed.) (Mineola, NY: Dover Publications).

Huhtamo, E. (1996). *Time Travelling in the Gallery: An Archaeological Approach in Media Art*. In: Moser, M.A. and MacLeod, D. (eds.) *Immersed in Technology: Art and Virtual Environments*. (Cambridge, MA: MIT Press):233-68.

Hultberg, T. (2001). *Sound Art: the Swedish Scene*. (Stockholm: STIM).

- Kahn, D. and Whitehead G. (eds.) (1996). *Wireless Imagination: Sound, Radio and the Avant-Garde*. (Cambridge, MA: MIT Press).
- Kahn, D. (1999). *Noise Water Meat*. (Cambridge, MA: MIT Press).
- Karlsson, H. (1998). Proceedings of the conference “Stockholm, Hey Listen!” (Stockholm: Royal Swedish Academy of Music).
- Kosovichev, A.G. et. al. (1996). Structure and Rotation of the Solar Interior: Initial Results from the MDI Medium – I Program [WWW] Available at http://soi.Stanford.edu/results/medl_2.ps [Accessed 24/11/2008]
- Kramer, G. et. al. (1999). *The Sonification Report: Status of the Field and Research Agenda*. (Santa Fe, NM: International Community for Auditory Display.) Available online at <http://www.icad.org/websiteV2.0/References/nsf.html> [Accessed 24/11/2008]
- Krueger, M.W. (1991). *Artificial Reality II*. (Reading, MA: Addison Wesley).
- Kubisch, C. (2000) *KlangRaumLichtZiet: Arbeiten von 1980 bis 2000*. (Heidelberg: Kehrer Verlag).
- Kubisch, C. (2007). Artist’s Statement. In: Collins, N. and d’Escrivan, J. (eds.) *The Cambridge Companion to Electronic Music*. (Cambridge: Cambridge University Press).
- Lander, D. and Lexier, M. (1990). *Sound by Artists*. (Toronto: Art Metropole).
- La Motte-Haber, H. de. (1996). *Klangkunst*. (Munchen: Prestel Verlag).
- La Motte-Haber, H. de. (1999). *Klangkunst. Tönende Objekte und klingende Räume* (Handbuch der Musik im 20. Jahrhundert; Bd. 12). (Laaber: Laaber-Verlag).
- Leitner, B. (1998). *Sound: Space*. (Ostfildern: Cantz).
- Levack Drever, J. (2002). *Soundscape Composition: The Convergence of*

- Ethnography and Acousmatic Music. *Organised Sound*, 7 (1): 21 – 27.
- Lucier, A. (1988). *Sferics*. [record sleeve notes] VR 1017 (New York: Lovely Music).
- Lundqvist, S. (1992). *Nobel Lectures: Physics 1971 – 1980*. (Singapore: World Scientific Publishing Co.).
- Manovich, L. (2002). *The Language of New Media*. (Cambridge, MA: MIT Press).
- Maur, K.V. (1999). *The Sound of Painting: Music in Modern Art*. (München: Prestel).
- McGinley, R. (2001). Stockholm Soundscape Project: New Directions in Music Education. In Levack-Drever, J. (ed.) *Proceedings: Sound Practice Conference* (Plymouth: University of Plymouth/UKISC).
- McGinley, R. (2002). The Earth's Original 4.5 Billion Year Old Electronic Music Composition (A Work in Progress). In Eacott, J (ed.) *Proceedings: Cybersonica Symposium*. (London: University of Westminster/ICA).
- McGinley, R. (2005). Stockholm Sound Sanctuaries Web Archive. [WWW] Available at www.interactive-agents.com/soundscape.html [Accessed 24/11/2008]
- McGinley, R. (2005). Stockholm Sound Sanctuaries: A Public Sound Art Project. In Bento Coelho, J.L. (ed.) *Proceedings: The 12th International Congress on Sound and Vibration*. (Lisbon: Instituto Superior Técnico/International Institute of Acoustics and Vibration).
- Millroth, T. (ed.) (2002). *Look at the Music/Seesound: En Lydkunst Antologi*. (Ystad: Ystads konstmuseum).
- Minard, R. (1999). *Silent Music: Between Sound Art and Acoustic Design*. (Heidelberg: Kehrler Verlag).
- Moeller, C. (2004). *A Time and Place: Media Architecture 1991 – 2003*. (Baden: Lars Müller Publishers).

Moser, M.A. and MacLeod, D. (eds.) (1996). *Immersed in Technology: Art and Virtual Environments*. (Cambridge, MA: MIT Press).

Muller, L. and Edwards, E. (2006). *Living Laboratories: Making and Curating Interactive Art* [WWW] Available at <http://www.siggraph.org/artdesign/gallery/S06/paper2.pdf> [Accessed 24/11/2008]

NASA (2008) Solar and Heliospheric Observatory (SOHO) Homepage [WWW] Available at <http://sohowww.nascom.nasa.gov/> [Accessed 24/11/2008]

O'Doherty, B. (1999). *Inside the White Cube: The Ideology of the Gallery Space*. (2nd Ed.) (Berkeley, CA: University of California Press).

Paine, G. (2002). Interactivity, where to from here. *Organised Sound*, 7 (3): 295 – 304.

Paterson, K. (2007). *Earth-Moon-Earth (Moonlight Sonata Reflected from the Surface of the Moon)* [WWW] Available at <http://www.katiepaterson.org/E.M.E/eme-info.html> [Accessed 24/11/2008]

Paine, G. (2007). *Sonic Immersion: Interactive engagement in realtime immersive environments*. [WWW] Available at <http://www.activatedspace.com/Papers/SonicImmersionSCAN.pdf> [Accessed 24/11/2008]

Positive Soundscapes Project (2006). *Positive Soundscapes Project* [WWW] Available at <http://www.positivesoundscapes.org/> [Accessed 24/11/2008]

Radioqualia (2004). *Radio Astronomy*. [WWW] Available at <http://www.radio-astronomy.net/> [Accessed 24/11/2008]

Retrofuturism. (1997) *Retrofuturism*. [WWW] Available at <http://pwp.detritus.net/in/1997/rf.html> [Accessed 24/11/2008]

Rhodes, E.J. et. al.(1996). *Measurements of Frequencies of Solar Oscillations from the MDI Medium – 1 Program* [WWW] Available at http://quake.stanford.edu/~sasha/PAPERS/ed_6.pdf [Accessed 24/11/2008]

Rich, O. (2002). WeatherPlayer. [WWW] Available at <http://www.weatherplayer.com/> [Accessed 24/11/2008]

Schafer, R.M. (1977). *The Tuning of the World*. (New York: Knopf).

Schechner, R. (2002). *Performance Studies: An Introduction*. (London: Routledge).

Schulz, B. (ed.) (2002). *Resonances: Aspects of Sound Art*. (Heidelberg: Kehrer Verlag).

Stiller, A. (1997). The Music in Blade Runner. In: Kerman, J (ed.) *Retrofitting Blade Runner* 2nd Edition. (Madison, WI: University of Wisconsin Press): 196 – 200.

Suderberg, E. (ed.) (2000). *Space, Site, Intervention: Situating Installation Art*. (Minneapolis, MN: University of Minnesota Press).

Sullivan, W.T. (1982). *Classics in Radio Astronomy*. (Dordrecht, Holland: D. Reidel Pub. Co. Ltd).

Taylor, T.D. (2003). *Strange Sounds: Music, Technology and Culture*. (New York: Routledge).

Toop, D. (2000). *Sonic Boom: The Art of Sound*. [exhibition catalogue] (London: Hayward Gallery).

Toop, D. (2004). *Haunted Weather: Music, Silence and Memory*. (London: Serpent's Tail).

Truax, B. (1984). *Acoustic Communication*. (Norwood, NJ: Ablex Publishing Corp.).

Truax, B. (2008). Soundscape Composition as Global Music: Electroacoustic Music as Soundscape. *Organised Sound*, 13 (2): 103 – 109.

Westerkamp, H. (2002). Linking Soundscape Composition and Acoustic Ecology. *Organised Sound*, 7 (1): 51 – 56.

- Whittle, M. (2008). Homepage. [WWW] Available at <http://www.astro.virginia.edu/~dmw8f/> [Accessed 24/11/2008]
- Wierzbicki, J.E. (2005). Louis and Bebe Barron's Forbidden Planet: A Score Guide. (Lanham, MD: Scarecrow Press).
- Wilson, R.W. (1978). The Cosmic Microwave Background Radiation. In Lundqvist, S. (ed.) (1992). Nobel Lectures: Physics 1971 – 1980. (Singapore: World Scientific Publishing Co.): 465 – 483.
- Wilson, S. (2002). Information Arts: Intersections of Art, Science and Technology. (Cambridge, MA: MIT Press).
- Wishart, T. (1996). On Sonic Art. (2nd Ed.) (Amsterdam: Harwood Academic Publishers).
- Woolley, B. (1992). Virtual Worlds: A Journey in Hype and Hyperreality. (Oxford: Blackwell Publishers).
- Woolman, M. (2000). Sonic Graphics: Seeing Sound. (London: Thames and Hudson).
- World Forum for Acoustic Ecology (1993). The Tuning of the World : Proceedings of the First International Conference on Acoustic Ecology. (Banff: The Banff Centre).
- Wynne, J. (2004). Fallender Ton für 207 Lautsprecher Boxen. *Soundscape, the Journal of Acoustic Ecology*, 5 (11): 42 – 43.
- Young, R. (1999). Remote Viewer: An Interview with Robin Rimbaud. In: *The Wire*, 186 (London: The Wire).
- Young, R. (ed.)(2002). Undercurrents: The Hidden Wiring of Modern Music. (London: Continuum/The Wire).